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THE LABORATORY MILLIMETER-WAVE SPECTRUM OF METHYL FORMATE IN ITS GROUND TORSIONAL E STATE

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ABSTRACT

Over 250 rotational transitions of the internal rotor methyl formate ($HCOOCH_3$) in its ground ($v_t = 0$) degenerate (E) torsional substate have been measured in the millimeter-wave spectral region. These data and a number of E-state lines identified by several other workers have been analyzed using an extension of the classical principal-axis method in the high barrier limit. The resulting rotational constants allow accurate prediction of the $v_t = 0$ E substate methyl formate spectrum below 300 GHz between states with angular momentum $J \leq 30$ and rotational energy $E_{\text{rot}} \leq 350$ cm^{-1}. The calculated transition frequencies for the E state, when combined with the results of our previous analysis of the ground symmetric, nondegenerate (A) state, account for over 200 of the emission lines observed toward Orion in a recent survey of the 215–265 GHz band.

Subject headings: interstellar: molecules — laboratory spectra — line identifications — molecular processes — transition probabilities

I. INTRODUCTION

Identification of the molecular species responsible for the growing number of millimeter and submillimeter emission lines observed toward astronomical sources is crucial to our understanding of the interstellar medium. Many of the observed features have been assigned to a relatively small number of molecular species; in recent millimeter-wave studies of Orion performed by Johansson *et al.* (1984), Sutton *et al.* (1985), and Blake *et al.* (1986), a substantial fraction of such features was found to be due to three molecules: methyl formate, dimethyl ether, and methanol. In part, the prevalence of these species in the Orion spectrum is due to their common feature of internal rotation, which results in a large number of observable rotational transitions for each, especially if the source is a warm one.

Since the identification of less prevalent species via their often sparse rotational spectra is of vital interest, complete descriptions of the rather complicated spectra of these known constituents of the intersteller medium must be made. Some progress in measuring and understanding the spectra of interstellar internal rotors has been made (Lovas, Lutz, and Dreizler 1979; Bauder 1979; Herbst *et al.* 1984). However, internal rotation greatly increases the difficulty of accurately calculating the transition frequencies of molecules. Many observable transitions involve levels which are strongly affected by the rigid-body rotation–internal rotation interactions, and whose energies are difficult to determine to within the frequency resolution of current astronomical receivers. As the sensitivity of these receivers increases, large numbers of such transitions will have to be observed in the laboratory or reliably predicted if the identification of the less abundant species is to be accomplished.

We have previously provided an accurate list of the 2700 strongest transitions below 500 GHz of methyl formate in its ground torsional A (symmetric) state involving rotational states with angular momentum up to $J = 50$ and rotational energy below 350 cm^{-1} (Plummer *et al.* 1984). In this paper we present the laboratory millimeter-wave spectrum (up to 300 GHz) of methyl formate in its ground torsional E (degenerate) state, including those states with angular momentum $J \leq 30$ and $E_{\text{rot}} \leq 350$ cm^{-1}. Other measurements of the methyl formate rotational spectrum have been made by Curl (1959) in the 8–30 GHz band, by Bauder (1979) in the range up to 58 GHz, and by DeMaison *et al.* (1984) in the 220–240 GHz band; we have made extensive use of these authors' observations and assignments. Over 250 new E-state transitions have been measured in our laboratory, and an analysis of a combined data set of 364 E-state lines has been carried out. Table 1 lists the observed transitions, the calculated perturbations (P) due to the rotational–internal rotation interaction (see below), and the residuals (R) obtained in the fit. Our analyses differ from those of previous workers in that we handle the A and E states separately (rather than carrying out a global fit to the entire spectrum), and place emphasis on the accurate prediction of the ground-state rotational spectrum (rather than on the determination of molecular structural parameters). This approach has allowed greatly increased accuracy in fitting and in predicting the spectra, and is attractive also because most of the calculations required in the case of methyl formate can be carried out with existing principal-axis

TABLE 1

TRANSITIONS USED IN THE ANALYSIS

ASSIGNMENT	FREQUENCY	P	R
1(1, 0)- 1(1, 1)	1610.91	1.7	0.02
1(0, 1)- 0(0, 0)	12218.16	0.0	-0.01
1(1, 0)- 1(0, 1)	14676.76	0.9	0.05
1(1, 1)- 0(0, 0)	25284.04	-0.9	0.04
2(0, 2)- 1(0, 1)	24296.52	0.0	-0.03
2(1, 2)- 1(1, 1)	22827.77	0.6	0.00
2(1, 1)- 1(1, 0)	26044.83	-0.6	0.03
2(1, 1)- 2(0, 2)	16425.07	0.3	0.10
2(1, 2)- 1(0, 1)	35893.64	-0.3	0.05
2(0, 2)- 1(1, 1)	11230.66	0.9	-0.06
3(1, 2)- 3(1, 3)	9647.16	0.3	0.05
3(0, 3)- 2(0, 2)	36102.29	0.0	0.04
3(1, 3)- 2(1, 2)	34156.91	0.1	0.02
3(1, 2)- 2(1, 1)	38976.13	-0.1	0.06
3(2, 2)- 2(2, 1)	36678.59	24.1	0.03
3(2, 1)- 2(2, 0)	37182.13	-24.1	0.03
3(1, 2)- 3(0, 3)	19298.93	0.1	0.13
3(2, 2)- 3(1, 3)	46517.29	-7.4	0.09
3(2, 1)- 3(1, 2)	37576.55	7.4	0.04
3(1, 3)- 2(0, 2)	45754.05	-0.1	0.11
3(0, 3)- 2(1, 2)	24505.10	0.3	-0.10
4(1, 3)- 4(1, 4)	16037.31	0.2	0.04
4(0, 4)- 3(0, 3)	47534.17	0.0	0.05
4(1, 4)- 3(1, 3)	45395.83	0.1	0.03
4(2, 3)- 3(2, 2)	48768.24	5.1	0.00
4(2, 2)- 3(2, 1)	50094.97	-5.1	0.08
4(3, 2)- 3(3, 1)	49151.78	20.9	0.14
4(3, 1)- 3(3, 0)	49155.22	-20.9	-0.05
4(1, 3)- 4(0, 4)	23550.76	0.1	0.12
4(2, 3)- 4(1, 4)	49889.74	-2.4	0.09
4(2, 2)- 4(1, 3)	35885.47	2.4	0.03
4(1, 4)- 3(0, 3)	55047.55	-0.1	0.07
4(0, 4)- 3(1, 3)	37882.36	0.1	-0.07
4(1, 3)- 3(2, 2)	14915.87	7.6	0.00
5(1, 4)- 5(1, 5)	23923.89	0.1	-0.01
5(1, 5)- 4(1, 4)	56529.92	0.0	0.02
5(1, 4)- 5(0, 5)	29401.53	0.1	0.07
5(2, 4)- 5(1, 5)	54140.19	-1.0	0.12
5(0, 5)- 4(1, 4)	51052.20	0.1	-0.13
5(5, 0)- 4(4, 1)	186238.70	304.8	-0.44
5(5, 1)- 4(4, 0)	185629.61	-304.8	0.48
6(1, 5)- 6(1, 6)	33164.24	0.1	-0.09
6(2, 4)- 6(2, 5)	8570.75	1.0	0.06
6(1, 5)- 6(0, 6)	36927.86	0.0	0.01
6(2, 4)- 6(1, 5)	34671.76	0.5	0.15
6(1, 5)- 5(2, 4)	46579.83	1.1	-0.08
7(1, 6)- 7(1, 7)	43528.06	0.1	-0.14
7(2, 5)- 7(2, 6)	14267.30	0.6	0.06
7(1, 6)- 7(0, 7)	45989.38	0.0	-0.03
7(2, 5)- 7(1, 6)	35974.32	0.2	0.23
7(5, 2)- 6(4, 3)	210725.45	286.3	-0.34
8(2, 6)- 8(2, 7)	21663.14	0.3	0.03
8(2, 6)- 8(1, 7)	38958.63	0.1	0.22
8(3, 5)- 8(2, 6)	57612.66	2.6	0.08
8(8, 0)- 8(7, 1)	207570.22	16.6	-0.08
8(4, 4)- 7(3, 5)	195524.55	76.0	0.23
8(4, 5)- 7(3, 4)	193690.96	-76.0	-0.32
8(5, 3)- 7(4, 4)	222925.35	260.4	-0.38
9(2, 7)- 9(2, 8)	30670.58	0.2	-0.02
9(2, 7)- 9(1, 8)	43829.18	0.1	0.16
9(3, 6)- 9(2, 7)	54810.96	1.2	0.01
9(8, 1)- 9(7, 2)	207491.71	16.2	0.02
9(4, 5)- 8(3, 6)	208326.19	36.3	0.28
9(4, 6)- 8(3, 5)	204619.98	-36.3	-0.18
9(5, 4)- 8(4, 5)	235087.75	214.4	0.17
9(5, 5)- 8(4, 4)	234479.41	-214.4	-0.27
10(3, 7)-10(3, 8)	10466.11	1.4	0.08
10(2, 8)-10(1, 9)	50674.72	0.1	0.08
10(3, 7)-10(2, 8)	52952.38	0.6	0.19
10(8, 3)-10(7, 4)	207350.57	-15.9	0.07
10(8, 2)-10(7, 3)	207382.10	15.9	-0.12
10(10, 1)-10(9, 2)	262834.78	-6.6	0.39
10(10, 0)-10(9, 1)	262847.22	6.6	-0.33
10(4, 7)- 9(3, 6)	214622.85	-15.8	-0.17
10(5, 5)- 9(4, 6)	247242.37	161.2	0.33
11(2, 9)-11(2,10)	52761.82	0.1	-0.14
11(3, 8)-11(3, 9)	16618.31	0.7	0.10
11(3, 8)-11(2, 9)	52543.40	0.3	0.25
11(8, 4)-11(7, 5)	207203.93	-15.5	0.12
11(9, 3)-11(8, 4)	235025.83	-11.1	0.19
11(10, 2)-11(9, 3)	262769.79	-6.5	0.32
11(10, 1)-11(9, 2)	262782.10	6.5	-0.28
11(4, 8)-10(3, 7)	223465.34	-7.1	-0.05
11(5, 6)-10(4, 7)	259445.45	111.8	0.48
11(5, 7)-10(4, 6)	258152.48	-111.8	-0.45
12(3, 9)-12(3,10)	24625.17	0.4	0.08
12(3, 9)-12(2,10)	53974.70	0.2	0.26
12(8, 4)-12(7, 5)	207041.41	15.2	0.07
12(9, 4)-12(8, 5)	234898.99	-10.8	0.09
12(10, 2)-12(9, 3)	262695.68	6.3	-0.09
12(5, 7)-11(4, 8)	271780.34	64.5	0.58
12(5, 8)-11(4, 7)	269404.04	-64.5	-0.73
13(0,13)-12(0,12)	142815.47	0.0	0.03
13(1,12)-12(1,11)	153512.70	0.0	0.04
13(2,11)-12(2,10)	164955.67	0.0	-0.02
13(3,11)-12(3,10)	158693.67	0.1	-0.01
13(3,10)-12(3, 9)	168495.01	-0.1	-0.05
13(9, 5)-12(9, 4)	159782.76	8.1	-0.23
13(9, 4)-12(9, 3)	159766.82	-8.1	0.05
13(10, 4)-12(10, 3)	159670.86	8.3	-0.31
13(10, 3)-12(10, 2)	159654.88	-8.3	0.21
13(11, 3)-12(11, 2)	159592.30	8.2	-0.49
13(11, 2)-12(11, 1)	159576.65	-8.2	0.30
13(8, 6)-13(7, 7)	206763.68	-15.0	-0.03
13(8, 5)-13(7, 6)	206793.01	15.0	-0.06
13(9, 5)-13(8, 6)	234735.65	-10.6	-0.01
13(10, 4)-13(9, 5)	262571.46	-6.2	0.14
13(12, 2)-13(11, 3)	318017.30	3.3	0.80
13(12, 1)-13(11, 2)	318009.01	-3.3	-0.93
13(0,13)-12(1,12)	142624.48	0.0	0.00
13(1,12)-12(2,11)	149065.24	0.1	-0.05
13(4, 9)-12(3,10)	268671.98	1.7	0.10
13(4,10)-12(3, 9)	237297.09	-1.7	0.06
13(5, 8)-12(4, 9)	284398.68	30.9	0.48
13(5, 9)-12(4, 8)	279974.89	-30.9	-0.48
14(8, 7)-14(7, 8)	206451.37	-15.4	-0.08
14(8, 6)-14(7, 7)	206480.04	15.4	0.04
14(9, 6)-14(8, 7)	234529.39	-10.3	-0.07
14(10, 5)-14(9, 6)	262429.54	-6.0	0.00
14(10, 4)-14(9, 5)	262441.80	6.0	0.21
14(12, 3)-14(11, 4)	317945.17	3.0	0.34
14(12, 2)-14(11, 3)	317938.45	-3.0	-0.30
15(8, 8)-15(7, 9)	206063.19	-16.8	-0.11
15(8, 7)-15(7, 8)	206091.08	16.8	0.03
15(9, 7)-15(8, 8)	234273.12	-10.0	-0.11
15(10, 6)-15(9, 7)	262252.71	-5.9	-0.19
15(11, 5)-15(10, 6)	290097.68	-1.6	-0.08
15(11, 4)-15(10, 5)	290100.89	1.6	-0.14
15(12, 4)-15(11, 5)	317854.48	2.8	0.06
15(12, 3)-15(11, 4)	317848.69	-2.8	-0.16
15(4,12)-14(3,11)	246675.42	-0.5	0.07
16(8, 9)-16(7,10)	205586.84	-20.6	-0.04
16(8, 8)-16(7, 9)	205613.39	20.6	-0.19
16(9, 8)-16(8, 9)	233959.01	-9.9	-0.16
16(10, 6)-16(9, 7)	262047.84	5.7	0.25
16(11, 6)-16(10, 7)	289943.65	-1.7	0.18
16(11, 5)-16(10, 6)	289947.53	1.7	0.69
16(12, 5)-16(11, 6)	317742.45	2.5	0.03
16(12, 4)-16(11, 5)	317737.42	-2.5	0.04
17(0,17)-16(0,16)	185176.80	0.0	-0.02
17(1,17)-16(1,16)	185168.22	0.0	-0.01
17(1,16)-16(1,15)	195139.87	0.0	0.02
17(2,16)-16(2,15)	194864.97	0.0	0.01
17(8, 9)-17(7,10)	205032.63	29.1	-0.18
17(9, 9)-17(8,10)	233578.52	-10.0	-0.17
17(10, 8)-17(9, 9)	261773.07	-5.6	-0.34
17(10, 7)-17(9, 8)	261784.95	5.6	0.33
17(11, 7)-17(10, 8)	289755.76	-1.7	-0.28
17(11, 6)-17(10, 7)	289759.92	1.7	0.39
17(12, 6)-17(11, 7)	317605.78	2.2	0.02
17(12, 5)-17(11, 6)	317601.25	-2.2	-0.04
17(1,17)-16(0,16)	185187.42	0.0	-0.03
17(0,17)-16(1,16)	185157.60	0.0	-0.01
18(0,18)-17(0,17)	195773.35	0.0	-0.04
18(1,18)-17(1,17)	195768.59	0.0	-0.02
18(2,17)-18(1,18)	162248.07	0.0	-0.05
18(8,11)-18(7,12)	204316.05	-44.6	0.50
18(8,10)-18(7,11)	204329.01	44.6	-0.37
18(9,10)-18(8,11)	233122.16	-10.8	-0.14
18(10, 9)-18(9,10)	261458.04	-5.5	-0.46
18(11, 7)-18(10, 8)	289535.22	1.8	0.57
18(12, 7)-18(11, 8)	317440.89	1.9	-0.27
18(12, 6)-18(11, 7)	317437.59	-1.9	0.32
18(1,18)-17(0,17)	195779.16	0.0	-0.06
18(0,18)-17(1,17)	195762.74	0.0	-0.03
18(4,15)-17(3,14)	256985.71	-0.1	0.08
19(4,16)-18(4,15)	233212.75	0.0	0.02
19(5,15)-18(5,14)	236743.68	0.3	0.06
19(6,14)-18(6,13)	236800.52	5.2	0.10
19(6,13)-18(6,12)	237807.63	-5.2	-0.05
19(7,13)-18(7,12)	235865.87	33.4	-0.16
19(7,12)-18(7,11)	235887.18	-33.4	0.23
19(8,11)-18(8,10)	235029.94	-13.1	-0.01
19(9,10)-18(9, 9)	234486.41	-11.0	-0.16
19(10,10)-18(10, 9)	234134.60	11.1	0.07
19(10, 9)-18(10, 8)	234112.33	-11.1	-0.09
19(11, 9)-18(11, 8)	233867.11	11.0	-0.04
19(11, 8)-18(11, 7)	233845.25	-11.0	0.03
19(12, 8)-18(12, 7)	233670.98	10.7	-0.10
19(12, 7)-18(12, 6)	233649.88	-10.7	0.10
19(13, 7)-18(13, 6)	233524.63	10.1	-0.24
19(13, 6)-18(13, 5)	233504.98	-10.1	0.27
19(14, 6)-18(14, 5)	233414.43	9.2	-0.33
19(14, 5)-18(14, 4)	233396.68	-9.2	0.39
19(15, 5)-18(15, 4)	233331.21	8.1	-0.35
19(15, 4)-18(15, 3)	233315.78	-8.1	0.44
19(16, 4)-18(16, 3)	233268.59	6.7	-0.33
19(16, 3)-18(16, 2)	233256.01	-6.7	0.50
19(17, 3)-18(17, 2)	233222.18	5.0	-0.17
19(1,18)-19(0,19)	171849.57	0.0	-0.34
19(3,17)-19(2,18)	153282.80	0.0	-0.30
19(8,12)-19(7,13)	203501.21	-64.9	0.39
19(8,11)-19(7,12)	203471.84	64.9	-0.53
19(9,11)-19(8,12)	232579.43	-12.9	-0.03
19(10,10)-19(9,11)	261084.12	-5.5	-0.44
19(10, 9)-19(9,10)	261095.68	5.5	0.36
19(11, 9)-19(10,10)	289263.19	-1.9	-0.46
19(12, 8)-19(11, 9)	317244.59	1.6	-0.50
19(3,17)-18(2,16)	229590.41	0.0	0.06
19(4,16)-18(3,15)	260793.54	-0.1	0.15
20(1,19)-19(1,18)	226773.13	0.0	-0.03
20(2,19)-19(2,18)	226713.06	0.0	0.02
20(2,18)-19(2,17)	237297.47	0.0	0.01
20(8,13)-19(8,12)	247704.32	16.2	-0.02
20(8,12)-19(8,11)	247682.63	-16.2	-0.01
20(9,12)-19(9,11)	247063.62	11.6	0.18
20(9,11)-19(9,10)	247040.58	-11.6	-0.18
20(10,11)-19(10,10)	246623.19	11.4	0.19
20(10,10)-19(10, 9)	246600.00	-11.4	-0.16
20(11,10)-19(11, 9)	246308.23	11.3	0.13
20(11, 9)-19(11, 8)	246285.34	-11.3	-0.14
20(12, 9)-19(12, 8)	246076.79	11.0	-0.01
20(12, 8)-19(12, 7)	246054.82	-11.0	-0.03
20(13, 8)-19(13, 7)	245903.68	10.4	-0.08
20(13, 7)-19(13, 6)	245883.10	-10.4	0.08
20(15, 6)-19(15, 5)	245672.98	8.3	-0.21
20(15, 5)-19(15, 4)	245656.78	-8.3	0.21
20(16, 5)-19(16, 4)	245597.30	6.8	-0.13
20(16, 4)-19(16, 3)	245583.97	-6.8	0.19
20(2,18)-20(1,19)	161380.18	0.0	-0.11
20(3,18)-20(2,19)	162926.85	0.0	0.88
20(8,13)-20(7,14)	202571.93	-77.6	0.33
20(8,12)-20(7,13)	202410.39	77.6	0.06
20(9,12)-20(8,13)	231938.66	-17.5	0.09
20(9,11)-20(8,12)	231955.22	17.5	-0.08
20(10,11)-20(9,12)	260643.80	-5.7	-0.31
20(10,10)-20(9,11)	260655.32	5.7	0.59
20(11,10)-20(10,11)	288948.23	-2.0	-0.53
20(11, 9)-20(10,10)	288953.41	2.0	0.65
20(12, 9)-20(11,10)	317013.36	1.3	-0.43
20(12, 8)-20(11, 9)	317011.71	-1.3	0.50
20(2,19)-19(1,18)	226856.82	0.0	0.02
20(1,19)-19(2,18)	226629.35	0.0	-0.05
20(3,18)-19(2,17)	238926.80	0.0	0.02
20(2,18)-19(3,17)	234726.53	0.0	-0.06
20(4,17)-19(3,16)	265352.73	0.0	0.12
20(4,16)-19(5,15)	188747.91	0.3	0.16
21(1,20)-20(1,19)	237344.87	0.0	-0.02
21(2,20)-20(2,19)	237309.54	0.0	0.01
21(3,19)-20(3,18)	247044.08	0.0	-0.03
21(3,18)-20(3,17)	260244.45	0.0	0.02
21(4,18)-20(4,17)	255776.10	0.0	-0.02
21(4,17)-20(4,16)	271524.69	0.0	-0.05
21(5,17)-20(5,16)	261148.86	0.1	0.01
21(5,16)-20(5,15)	271505.88	-0.1	-0.01
21(6,16)-20(6,15)	262324.85	1.0	0.05
21(6,15)-20(6,14)	265002.61	-1.0	-0.01
21(7,15)-20(7,14)	261436.73	16.5	0.24
21(7,14)-20(7,13)	261715.48	-16.5	-0.19
21(8,14)-20(8,13)	260404.03	21.2	-0.05
21(8,13)-20(8,12)	260384.28	-21.2	0.10
21(9,13)-20(9,12)	259653.01	12.3	0.18
21(9,12)-20(9,11)	259629.24	-12.3	-0.17
21(10,12)-20(10,11)	259137.93	11.8	0.26
21(10,11)-20(10,10)	259113.91	-11.8	-0.26

TABLE 1—*Continued*

ASSIGNMENT	FREQUENCY	P	R
21(11,11)-20(11,10)	258769.90	11.6	0.23
21(11,10)-20(11, 9)	258746.20	-11.6	-0.24
21(12,10)-20(12, 9)	258499.28	11.2	0.17
21(12, 9)-20(12, 8)	258476.45	-11.2	-0.17
21(13, 9)-20(13, 8)	258296.30	10.6	0.09
21(13, 8)-20(13, 7)	258274.95	-10.6	-0.04
21(14, 8)-20(14, 7)	258142.09	9.7	0.02
21(14, 7)-20(14, 6)	258122.66	-9.7	-0.05
21(15, 7)-20(15, 6)	258024.24	8.4	0.12
21(15, 6)-20(15, 5)	258007.15	-8.4	-0.09
21(16, 6)-20(16, 5)	257933.83	6.9	0.09
21(16, 5)-20(16, 4)	257919.89	-6.9	-0.07
21(17, 5)-20(17, 4)	257865.09	5.0	0.27
21(17, 4)-20(17, 3)	257854.46	-5.0	-0.30
21(1,20)-21(0,21)	191439.58	0.0	-0.39
21(2,20)-21(1,21)	191487.30	0.0	-0.01
21(2,19)-21(1,20)	171692.27	0.0	0.02
21(3,19)-21(2,20)	172660.49	0.0	-0.06
21(4,18)-21(3,19)	153618.19	0.0	-0.40
21(8,14)-21(7,15)	201539.16	-72.9	-0.02
21(8,13)-21(7,14)	201078.69	72.9	-0.15
21(9,13)-21(8,14)	231187.69	-26.5	0.37
21(9,12)-21(8,13)	231200.14	26.5	-0.38
21(10,12)-21(9,13)	260128.61	-6.2	-0.35
21(11,11)-21(10,12)	288580.17	-2.2	-0.58
21(11,10)-21(10,11)	288585.51	2.2	0.48
21(0,21)-20(1,20)	227559.93	0.0	-0.08
21(2,20)-20(1,19)	237393.19	0.0	0.02
21(1,20)-20(2,19)	237261.20	0.0	-0.05
21(4,18)-20(3,17)	270882.39	0.0	0.11
21(4,17)-20(5,16)	211241.57	0.1	0.03
22(1,21)-22(0,22)	201205.69	0.0	-0.20
22(2,21)-22(1,22)	201233.14	0.0	0.08
22(2,20)-22(1,21)	181851.05	0.0	0.05
22(3,20)-22(2,21)	182449.17	0.0	-0.05
22(3,19)-22(2,20)	156090.34	0.0	0.03
22(4,19)-22(3,20)	162747.54	0.0	-0.08

ASSIGNMENT	FREQUENCY	P	R
22(9,14)-22(8,15)	230315.80	-40.2	0.69
22(9,13)-22(8,14)	230312.31	40.2	-0.67
22(10,13)-22(9,14)	259529.94	-7.4	-0.15
22(10,12)-22(9,13)	259540.70	7.4	0.10
22(11,12)-22(10,13)	288153.18	-2.4	-0.44
22(11,11)-22(10,12)	288158.83	2.4	0.59
23(2,22)-23(1,23)	210974.24	0.0	-0.07
23(3,21)-23(2,22)	192266.02	0.0	-0.08
23(3,20)-23(2,21)	167685.30	0.0	0.02
23(5,19)-23(4,20)	155663.06	0.0	-0.01
23(6,18)-23(5,19)	153739.68	-0.1	-0.12
23(10,14)-23(9,15)	258837.62	-10.0	0.07
23(10,13)-23(9,14)	258848.06	10.0	0.08
23(11,13)-23(10,14)	287660.38	-2.7	-0.42
23(11,12)-23(10,13)	287666.31	2.7	0.44
23(4,20)-22(3,19)	285016.27	0.0	0.04
24(2,23)-24(1,24)	220710.47	0.0	0.19
24(4,21)-24(3,22)	181808.14	0.0	-0.11
24(5,20)-24(4,21)	163464.59	0.0	0.06
24(10,15)-24(9,16)	258040.80	-15.0	0.25
24(11,14)-24(10,15)	287094.79	-3.3	-0.38
24(11,13)-24(10,14)	287101.12	3.3	0.32
24(4,21)-23(3,20)	293410.36	0.0	0.32
24(4,20)-23(5,19)	272991.76	0.0	-0.06
25(1,24)-25(0,25)	230435.75	0.0	0.01
25(2,24)-25(1,25)	230440.77	0.0	0.07
25(2,23)-25(1,24)	211790.76	0.0	0.01
25(3,23)-25(2,24)	211922.89	0.0	0.07
25(3,22)-25(2,23)	189666.63	0.0	0.09
25(4,22)-25(3,23)	191584.42	0.0	0.20
25(4,21)-25(3,22)	156946.44	0.0	-0.08
25(6,20)-25(5,21)	162096.64	0.0	0.01
25(10,16)-25(9,17)	257129.35	-23.0	0.92
25(10,15)-25(9,16)	257131.34	23.0	-1.02
25(11,15)-25(10,16)	286448.86	-4.3	-0.06
25(11,14)-25(10,15)	286455.28	4.3	0.04
25(4,21)-24(5,20)	290695.50	0.0	0.07

ASSIGNMENT	FREQUENCY	P	R
26(1,25)-26(0,26)	240162.78	0.0	0.04
26(2,25)-26(1,26)	240165.61	0.0	0.09
26(2,24)-26(1,25)	221667.36	0.0	0.02
26(3,24)-26(2,25)	221746.11	0.0	0.33
26(3,23)-26(2,24)	200224.07	0.0	-0.03
26(4,23)-26(3,24)	201447.65	0.0	0.02
26(4,22)-26(3,23)	170093.15	0.0	-0.01
26(11,16)-26(10,17)	285713.95	-6.0	0.45
26(11,15)-26(10,16)	285720.24	6.0	-0.39
27(2,25)-27(1,26)	231513.06	0.0	-0.32
27(3,24)-27(2,25)	210589.20	0.0	-0.08
27(4,24)-27(3,25)	211359.94	0.0	0.16
27(6,22)-27(5,23)	174181.46	0.0	0.14
28(2,26)-28(2,27)	241334.84	0.0	0.07
28(1,27)-27(1,26)	311412.70	0.0	-0.20
28(2,27)-27(2,26)	311412.05	0.0	-0.15
28(8,21)-27(8,20)	350442.25	0.3	0.01
28(8,20)-27(8,19)	351823.45	-0.3	-0.15
28(9,20)-27(9,19)	348909.48	5.7	-0.16
28(9,19)-27(9,18)	349048.54	-5.7	-0.01
28(10,19)-27(10,18)	347628.34	17.1	0.44
28(10,18)-27(10,17)	347604.56	-17.1	-0.59
28(2,26)-28(1,27)	241335.67	0.0	0.04
28(3,25)-28(2,26)	220814.02	0.0	-0.08
28(4,25)-28(3,26)	221293.84	0.0	0.00
28(5,24)-28(4,25)	199694.88	0.0	0.09
29(0,29)-28(0,28)	312283.83	0.0	0.34
29(3,26)-29(2,27)	230936.32	0.0	-0.03
29(4,25)-29(3,26)	206102.49	0.0	-0.04
29(5,25)-29(4,26)	209489.63	0.0	-0.02
29(5,24)-29(4,25)	167850.85	0.0	0.03
29(6,24)-29(5,25)	189515.03	0.0	0.04
30(4,26)-30(3,27)	217194.35	0.0	-0.09
30(5,26)-30(4,27)	219417.27	0.0	-0.04
30(6,25)-30(5,26)	198145.58	0.0	0.07

NOTE.—Transition frequencies and residuals (R, observed minus calculated) in MHz. Calculated perturbation of the pseudorigid rotor frequencies due to internal rotation (P) in MHz.

system asymmetric rotor fitting routines. Diagonalization of extended rotational Hamiltonian matrices, as undertaken by Herbst *et al.* (1984), is not required.

II. EXPERIMENT AND THEORY

Measurements of the methyl formate spectrum have been carried out with our standard millimeter/submillimeter wave spectrometer. Briefly, a 40–60 GHz klystron is used to drive a waveguide-mounted silicon point-contact diode harmonic generator, which produces usable intensities of microwave power at multiples of the source frequency up to about 1 THz. After passing through a 2 m absorption cell containing $\sim$10 mTorr of the sample, the microwave radiation is detected by a 1.4 K InSb chip. As the source frequency is swept, the response of the chip is monitored, stored in a digital averager, and transferred to a computer for measurement and analysis. Details of our experimental techniques can be found in the literature (De Lucia 1976; Helminger, Messer, and De Lucia 1983).

The effective Hamiltonian used in our analysis of the acquired data has been discussed fully by Herschbach (1957, 1959). The standard principal-axis method (PAM) Hamiltonian for internal rotors was subjected to a Van Vleck transformation through ninth order using modern computational techniques. In the limit of a high potential barrier to the torsional motion of the methyl group, this transformation allows the approximate separation of the E and A problems. For a given torsional state v and symmetry σ ($\sigma = 0$ for the A state and $\sigma = 1, -1$ for the E states), the resulting effective Hamiltonian through ninth order is (Herschbach 1957, 1959)

$$\boldsymbol{H}_{v\sigma} = \boldsymbol{H}_{\text{rot}} + \boldsymbol{H}_{\text{dist}} + \boldsymbol{H}_{\text{tr}}, \tag{1}$$

TABLE 2

EFFECTIVE CONSTANTS OF $v_t = 0\ (E)$ $HCOOCH_3$[a]

Constant	Value	Constant	Value
A	19980.3907(105)	$L_{KKJ} \times 10^9$ ...	2.62(62)
B	6913.6822(23)	$F \times 10^{-3}$......	168.142(138)
C	5304.5114(21)	s	31.8288(63)
$\Delta_J \times 10^4$.......	58.895(25)	$\rho_a \times 10^3$	78.4580(945)
$\Delta_{JK} \times 10^4$	$-233.13(57)$	$\delta_F \times 10^2$.......	$-5.915(178)$
$\Delta_K \times 10^4$	754.009(749)	$\delta_\rho \times 10^6$	$-7.333(655)$
$\delta_J \times 10^4$	18.571(7)	$W_{01}^{(1)} \times 10^3$ ...	-2.85136
$\delta_K \times 10^4$.......	20.57(52)	$W_{01}^{(3)} \times 10^3$ ...	2.08631
$H_{JK} \times 10^7$	$-9.770(920)$	$W_{01}^{(5)} \times 10^4$ ...	-4.5909
$H_{KJ} \times 10^7$	$-34.11(46)$	$W_{01}^{(7)} \times 10^5$ ...	4.8583
$h_{JK} \times 10^7$......	$-3.35(74)$	$W_{01}^{(9)} \times 10^6$ ...	-2.959
$h_K \times 10^7$.......	$-6.40(59)$		
$L_{JK} \times 10^9$......	1.07(46)		

NOTE.—Number of observed transitions: 364; variance of fit: 0.25 MHz. Numbers in parentheses are 1 σ deviations.

[a] Number of significant digits needed to reproduce spectrum. Rotational constants and centrifugal distortion constants from A through F and δ_F are in MHz. All other parameters (s, ρ_a, δ_ρ, and the W_{01}) are dimensionless.

TABLE 3

TRANSITIONS FROM 1 TO 300 GHz

ASSIGNMENT	FREQUENCY	S	E	ASSIGNMENT	FREQUENCY	S	E	ASSIGNMENT	FREQUENCY	S	E
30(9,21)-30(9,22)	1038.43 (0.02)	4.7	229	25(6,19)-25(6,20)	34476.02 (0.14)	1.8	152	14(4,10)-14(3,11)	71988.46 (0.03)	10.4	51
26(8,18)-26(8,19)	1138.32 (0.03)	4.3	174	6(2, 4)- 6(1, 5)	34671.59 (0.02)	5.1	11	6(2, 5)- 5(2, 4)	72680.83 (0.02)	5.3	10
14(5, 9)-14(5,10)	1171.72 (0.03)	3.2	55	21(5,16)-21(5,17)	35854.29 (0.10)	1.5	108	6(1, 6)- 5(0, 5)	73033.20 (0.02)	4.4	8
22(7,15)-22(7,16)	1211.83 (0.05)	3.9	127	7(2, 5)- 7(1, 6)	35974.08 (0.02)	6.1	14	6(5, 1)- 5(5, 0)	73658.27 (0.02)	1.8	20
18(6,12)-18(6,13)	1233.45 (0.04)	3.6	87	17(4,13)-17(4,14)	35978.61 (0.08)	1.2	72	6(5, 2)- 5(5, 1)	73663.99 (0.02)	1.8	20
7(3, 4)- 7(3, 5)	1528.73 (0.01)	2.3	16	3(0, 3)- 2(0, 2)	36102.25 (0.01)	3.0	2	6(4, 2)- 5(4, 1)	73783.00 (0.02)	3.3	16
1(1, 0)- 1(1, 1)	1610.89 (0.00)	1.5	1	3(2, 2)- 2(2, 1)	36678.57 (0.02)	1.7	4	6(4, 3)- 5(4, 2)	73787.60 (0.02)	3.3	16
27(8,19)-27(8,20)	1986.88 (0.03)	4.0	186	3(2, 1)- 2(2, 0)	37182.10 (0.02)	1.7	4	6(3, 4)- 5(3, 3)	73905.90 (0.03)	4.5	13
11(4, 7)-11(4, 8)	2003.24 (0.01)	2.6	35	8(2, 6)- 8(1, 7)	38958.41 (0.02)	6.7	17	6(3, 3)- 5(3, 2)	74263.48 (0.03)	4.5	13
4(2, 2)- 4(2, 3)	2033.07 (0.01)	1.7	6	3(1, 2)- 2(1, 1)	38976.08 (0.01)	2.7	3	13(4, 9)-13(3,10)	75551.69 (0.03)	9.0	45
23(7,16)-23(7,17)	2149.26 (0.03)	3.7	137	9(2, 7)- 9(1, 8)	43829.02 (0.03)	7.0	21	15(3,13)-16(0,16)	75552.64 (0.11)	0.0	53
15(5,10)-15(5,11)	2213.28 (0.02)	2.9	61	30(7,23)-30(7,24)	44333.72 (0.33)	2.0	217	18(4,14)-18(3,15)	75652.72 (0.05)	14.1	79
19(6,13)-19(6,14)	2240.70 (0.03)	3.3	95	4(1, 4)- 3(1, 3)	45395.80 (0.02)	3.7	4	7(0, 7)- 6(1, 6)	76018.17 (0.03)	5.2	11
8(3, 5)- 8(3, 6)	3216.48 (0.01)	2.0	19	14(3,11)-14(3,12)	45847.38 (0.07)	0.8	49	20(4,16)-20(4,17)	76670.59 (0.11)	0.9	96
28(8,20)-28(8,21)	3368.24 (0.04)	3.8	197	26(6,20)-26(6,21)	46920.02 (0.17)	1.7	164	6(2, 4)- 5(2, 3)	76701.82 (0.02)	5.3	11
24(7,17)-24(7,18)	3694.07 (0.03)	3.4	147	4(0, 4)- 3(0, 3)	47534.12 (0.02)	4.0	4	23(14, 9)-24(13,12)	76794.92 (0.57)	1.2	203
12(4, 8)-12(4, 9)	3806.25 (0.01)	2.3	40	18(4,14)-18(4,15)	48072.09 (0.09)	1.1	79	6(1, 5)- 5(1, 4)	76796.09 (0.02)	5.8	10
20(6,14)-20(6,15)	3927.19 (0.03)	3.0	103	22(5,17)-22(5,18)	48291.36 (0.12)	1.4	118	28(6,22)-28(6,23)	77870.92 (0.27)	1.4	188
16(5,11)-16(5,12)	3997.30 (0.02)	2.7	68	4(2, 3)- 3(2, 2)	48768.25 (0.02)	3.0	6	24(5,19)-24(5,20)	78377.44 (0.15)	1.2	138
17(7,11)-16(8, 8)	4548.55 (0.23)	1.4	85	4(3, 2)- 3(3, 1)	49151.64 (0.02)	1.8	8	21(4,18)-22(2,21)	78377.47 (0.09)	0.0	102
5(2, 3)- 5(2, 4)	4549.71 (0.01)	1.4	8	4(3, 1)- 3(3, 0)	49155.27 (0.02)	1.8	8	7(1, 7)- 6(1, 6)	78479.38 (0.03)	6.8	11
2(1, 1)- 2(1, 2)	4827.93 (0.00)	0.8	2	4(2, 2)- 3(2, 1)	50094.90 (0.02)	3.0	6	9(3, 7)- 9(2, 8)	79401.70 (0.03)	4.6	23
29(8,21)-29(8,22)	5538.50 (0.07)	3.5	210	10(2, 8)-10(1, 9)	50674.63 (0.04)	6.9	25	7(0, 7)- 6(0, 6)	79781.68 (0.03)	6.9	11
9(3, 6)- 9(3, 7)	6079.82 (0.02)	1.7	23	4(1, 3)- 3(1, 2)	51785.97 (0.02)	3.7	5	12(4, 8)-12(3, 9)	79840.81 (0.04)	7.7	40
25(7,18)-25(7,19)	6131.78 (0.05)	3.2	157	11(3, 8)-11(2, 9)	52543.12 (0.02)	9.0	32	13(2,11)-13(1,12)	81167.92 (0.06)	6.3	41
21(6,15)-21(6,16)	6605.01 (0.04)	2.8	112	10(3, 7)-10(2, 8)	52952.16 (0.02)	7.9	27	16(3,13)-16(2,14)	81314.20 (0.07)	10.0	62
13(4, 9)-13(4,10)	6749.78 (0.02)	2.0	45	12(3, 9)-12(2,10)	53974.42 (0.02)	9.9	37	7(1, 7)- 6(0, 6)	82242.89 (0.03)	5.3	11
17(5,12)-17(5,13)	6858.04 (0.03)	2.4	75	9(3, 6)- 9(2, 7)	54810.91 (0.03)	6.6	23	19(4,15)-19(3,16)	82523.26 (0.07)	14.0	88
6(2, 4)- 6(2, 5)	8570.69 (0.01)	1.1	11	5(1, 5)- 4(1, 4)	56529.90 (0.02)	4.8	6	10(3, 8)-10(2, 9)	83605.14 (0.03)	5.0	27
30(8,22)-30(8,23)	8828.07 (0.12)	3.3	222	13(3,10)-13(2,11)	57513.79 (0.03)	10.4	43	11(4, 7)-11(3, 8)	84224.57 (0.04)	6.6	35
26(7,19)-26(7,20)	9819.00 (0.07)	2.9	168	8(3, 5)- 8(2, 6)	57612.55 (0.03)	5.4	19	7(2, 6)- 6(2, 5)	84449.17 (0.02)	6.4	13
10(3, 7)-10(3, 8)	10466.03 (0.02)	1.4	27	5(0, 5)- 4(0, 4)	58565.70 (0.02)	4.9	6	21(5,16)-21(4,17)	85761.59 (0.05)	16.9	108
22(6,16)-22(6,17)	10647.70 (0.05)	2.5	122	15(3,12)-15(3,13)	58626.18 (0.08)	0.8	55	20(5,15)-20(4,16)	85780.44 (0.05)	15.8	99
18(5,13)-18(5,14)	11173.78 (0.04)	2.2	83	11(2, 9)-11(1,10)	59405.79 (0.04)	6.7	30	7(6, 1)- 6(6, 0)	85919.15 (0.03)	1.9	28
14(4,10)-14(4,11)	11203.03 (0.03)	1.8	51	5(2, 4)- 4(2, 3)	60780.32 (0.02)	4.2	8	7(6, 2)- 6(6, 1)	85926.66 (0.03)	1.9	28
1(0, 1)- 0(0, 0)	12218.17 (0.00)	1.0	0	5(4, 1)- 4(4, 0)	61401.05 (0.02)	1.8	14	7(5, 2)- 6(5, 1)	86021.08 (0.03)	3.4	23
7(2, 5)- 7(2, 6)	14267.25 (0.02)	0.9	14	5(4, 2)- 4(4, 1)	61405.12 (0.02)	1.8	14	7(5, 3)- 6(5, 2)	86027.80 (0.03)	3.4	23
27(7,20)-27(7,21)	15154.48 (0.11)	2.7	180	27(6,21)-27(6,22)	61488.10 (0.22)	1.5	175	7(4, 3)- 6(4, 2)	86223.61 (0.03)	4.7	19
23(6,17)-23(6,18)	16443.42 (0.08)	2.3	131	5(3, 3)- 4(3, 2)	61535.11 (0.02)	3.2	10	7(4, 4)- 6(4, 3)	86224.22 (0.03)	4.7	19
11(3, 8)-11(3, 9)	16618.22 (0.04)	1.2	32	5(3, 2)- 4(3, 1)	61612.36 (0.02)	3.2	10	7(3, 5)- 6(3, 4)	86268.73 (0.03)	5.7	16
19(5,14)-19(5,15)	17301.67 (0.06)	1.9	91	19(4,15)-19(4,16)	61750.98 (0.10)	1.0	88	7(3, 4)- 6(3, 3)	87143.29 (0.03)	5.7	16
15(4,11)-15(4,12)	17472.96 (0.05)	1.6	57	23(5,18)-23(5,19)	62578.90 (0.14)	1.2	128	8(0, 8)- 7(1, 7)	87766.42 (0.03)	6.2	14
8(2, 6)- 8(2, 7)	21663.11 (0.03)	0.8	17	5(2, 3)- 4(2, 2)	63296.96 (0.02)	4.2	8	19(5,14)-19(4,15)	88053.80 (0.05)	14.3	91
28(7,21)-28(7,22)	22520.65 (0.16)	2.4	192	14(3,11)-14(2,12)	63300.34 (0.04)	10.5	49	10(4, 6)-10(3, 7)	88175.37 (0.04)	5.6	30
2(1, 2)- 1(1, 1)	22827.77 (0.01)	1.5	2	5(1, 4)- 4(1, 3)	64416.52 (0.02)	4.8	7	22(5,17)-22(4,18)	88337.51 (0.07)	17.5	118
2(0, 2)- 1(0, 1)	24296.55 (0.01)	2.0	1	6(1, 6)- 5(1, 5)	67555.64 (0.02)	5.8	8	11(3, 9)-11(2,10)	88686.87 (0.03)	5.3	31
24(6,18)-24(6,19)	24321.54 (0.10)	2.1	142	6(0, 6)- 5(0, 5)	69269.69 (0.02)	5.9	8	7(1, 6)- 6(1, 5)	88843.24 (0.03)	6.8	12
12(3, 9)-12(3,10)	24625.09 (0.05)	1.1	37	24(8,17)-23(9,14)	69270.69 (0.27)	2.5	153	8(1, 8)- 7(1, 7)	89314.64 (0.03)	7.8	14
20(5,15)-20(5,16)	25497.27 (0.08)	1.7	99	16(4,12)-16(3,13)	69417.75 (0.03)	12.9	64	7(2, 5)- 6(2, 4)	90145.72 (0.03)	6.4	14
16(4,12)-16(4,13)	25730.22 (0.06)	1.4	64	4(3, 2)- 4(2, 3)	69723.64 (0.06)	1.7	8	8(0, 8)- 7(0, 7)	90227.63 (0.03)	7.9	14
2(1, 1)- 1(1, 0)	26044.81 (0.01)	1.5	2	12(2,10)-12(1,11)	69724.88 (0.05)	6.5	35	9(4, 5)- 9(3, 6)	91366.30 (0.05)	4.8	26
29(7,22)-29(7,23)	32205.52 (0.23)	2.2	204	15(4,11)-15(3,12)	69771.04 (0.03)	11.8	57	8(1, 8)- 7(0, 7)	91775.86 (0.03)	6.3	14
3(1, 3)- 2(1, 2)	34156.89 (0.01)	2.7	3	17(4,13)-17(3,14)	71303.75 (0.04)	13.7	72	20(4,16)-20(3,17)	91776.73 (0.08)	13.7	96
13(3,10)-13(3,11)	34426.48 (0.06)	0.9	43	15(3,12)-15(2,13)	71309.84 (0.06)	10.4	55	18(5,13)-18(4,14)	92073.90 (0.05)	12.8	83

TABLE 3—*Continued*

ASSIGNMENT	FREQUENCY	S	E	ASSIGNMENT	FREQUENCY	S	E	ASSIGNMENT	FREQUENCY	S	E
21(4,17)-21(4,18)	92419.20 (0.11)	0.9	105	10(1,10)- 9(1, 9)	110788.64 (0.03)	9.8	21	15(5,11)-15(4,12)	123305.50 (0.04)	8.4	61
17(3,14)-17(2,15)	92884.28 (0.07)	9.7	69	9(5, 4)- 8(5, 3)	110873.90 (0.03)	6.2	30	11(1,10)-10(2, 9)	123366.28 (0.03)	5.8	28
14(2,12)-14(1,13)	93205.90 (0.06)	6.1	47	9(3, 7)- 8(3, 6)	110879.77 (0.03)	8.0	23	10(5, 5)- 9(5, 4)	123377.94 (0.03)	7.5	34
23(5,18)-23(4,19)	93670.86 (0.08)	17.7	128	9(5, 5)- 8(5, 4)	110882.42 (0.03)	6.2	30	10(5, 6)- 9(5, 5)	123385.33 (0.03)	7.5	34
12(3,10)-12(2,11)	94626.85 (0.04)	5.5	36	15(4,12)-15(3,13)	110924.26 (0.04)	8.0	57	10(4, 7)- 9(4, 6)	123745.96 (0.03)	8.4	30
25(5,20)-25(5,21)	95267.32 (0.16)	1.1	149	10(0,10)- 9(0, 9)	111169.87 (0.03)	9.8	21	10(4, 6)- 9(4, 5)	124246.73 (0.03)	8.4	30
29(6,23)-29(6,24)	95655.02 (0.33)	1.3	200	9(4, 6)- 8(4, 5)	111223.49 (0.03)	7.2	26	16(5,12)-16(4,13)	124467.04 (0.04)	9.0	68
8(2, 7)- 7(2, 6)	96070.73 (0.03)	7.5	16	9(4, 5)- 8(4, 4)	111408.43 (0.03)	7.2	26	23(4,19)-23(4,20)	124571.08 (0.10)	0.9	125
9(4, 6)- 9(3, 7)	96956.84 (0.04)	4.7	26	9(1, 8)- 8(1, 7)	111674.13 (0.03)	8.7	20	26(5,21)-26(4,22)	124780.51 (0.13)	16.5	160
17(5,12)-17(4,13)	97199.02 (0.05)	11.4	75	28(6,22)-28(5,23)	111717.76 (0.15)	21.3	188	16(3,14)-16(2,15)	125508.69 (0.05)	5.9	60
10(4, 7)-10(3, 8)	97651.35 (0.03)	5.3	30	10(1,10)- 9(0, 9)	111733.94 (0.03)	8.3	21	20(6,14)-20(5,15)	126281.98 (0.07)	12.4	103
8(7, 1)- 7(7, 0)	98182.25 (0.04)	1.9	37	25(5,20)-25(4,21)	112256.44 (0.11)	17.0	149	17(5,13)-17(4,14)	126319.60 (0.04)	9.6	75
8(7, 2)- 7(7, 1)	98191.61 (0.04)	1.9	37	14(5, 9)-14(4,10)	112672.54 (0.04)	8.0	55	10(3, 7)- 9(3, 6)	127437.67 (0.03)	9.1	27
8(6, 2)- 7(6, 1)	98270.44 (0.03)	3.5	31	26(5,21)-26(5,22)	112771.80 (0.18)	1.1	160	23(9,15)-24(7,18)	128505.51 (0.21)	0.0	151
8(6, 3)- 7(6, 2)	98279.02 (0.03)	3.5	31	22(6,16)-22(5,17)	113313.59 (0.08)	15.1	122	27(7,20)-27(6,21)	128505.99 (0.17)	19.0	180
8(5, 3)- 7(5, 2)	98424.16 (0.03)	4.9	26	9(3, 6)- 8(3, 5)	113743.10 (0.03)	8.0	23	17(2,15)-17(1,16)	128880.92 (0.06)	6.0	66
8(5, 4)- 7(5, 3)	98431.88 (0.03)	4.9	26	30(6,24)-30(6,25)	114354.07 (0.38)	1.2	213	18(5,14)-18(4,15)	128972.21 (0.05)	10.2	82
8(3, 6)- 7(3, 5)	98606.85 (0.03)	6.9	19	22(4,18)-22(3,19)	115822.82 (0.09)	12.8	115	18(4,15)-18(3,16)	129058.20 (0.05)	8.7	78
8(4, 5)- 7(4, 4)	98712.06 (0.03)	6.0	22	16(4,13)-16(3,14)	116115.30 (0.04)	8.3	63	10(2, 8)- 9(2, 7)	129296.42 (0.03)	9.6	25
8(4, 4)- 7(4, 3)	98747.87 (0.03)	6.0	22	13(5, 8)-13(4, 9)	116385.96 (0.05)	7.1	49	23(4,19)-23(3,20)	129439.63 (0.09)	12.5	125
11(4, 8)-11(3, 9)	98839.56 (0.03)	6.0	35	9(2, 7)- 8(2, 6)	116544.75 (0.03)	8.6	21	12(4, 9)-12(2,10)	130008.98 (0.05)	0.0	40
9(0, 9)- 8(1, 8)	99133.29 (0.03)	7.3	17	30(7,23)-30(6,24)	116558.14 (0.21)	23.8	217	11(2,10)-10(2, 9)	130010.10 (0.03)	10.5	28
9(1, 9)- 8(1, 8)	100078.59 (0.03)	8.8	17	15(3,13)-15(2,14)	116917.98 (0.05)	5.8	53	27(5,22)-27(5,23)	130388.62 (0.19)	1.0	172
8(3, 5)- 7(3, 4)	100294.61 (0.03)	6.9	19	16(2,14)-16(1,15)	117310.01 (0.06)	6.0	59	20(3,17)-20(2,18)	131409.73 (0.07)	9.1	93
8(1, 7)- 7(1, 6)	100482.27 (0.03)	7.8	16	29(7,22)-29(6,23)	118245.29 (0.20)	22.4	204	12(0,12)-11(1,11)	131914.52 (0.03)	10.4	29
12(4, 9)-12(3,10)	100659.65 (0.03)	6.6	40	19(3,16)-19(2,17)	118460.73 (0.07)	9.2	85	10(2, 9)- 9(1, 8)	132006.43 (0.03)	5.1	24
9(0, 9)- 8(0, 8)	100681.51 (0.03)	8.9	17	10(2, 9)- 9(2, 8)	118848.01 (0.03)	9.5	24	12(1,12)-11(1,11)	132105.48 (0.03)	11.8	29
25(6,19)-25(5,20)	101305.29 (0.09)	19.8	152	12(5, 7)-12(4, 8)	119175.71 (0.05)	6.3	44	19(6,13)-19(5,14)	132244.03 (0.07)	11.3	95
13(3,11)-13(2,12)	101370.51 (0.04)	5.7	41	21(6,15)-21(5,16)	119778.72 (0.08)	13.7	112	12(0,12)-11(0,11)	132245.10 (0.03)	11.8	29
9(1, 9)- 8(0, 8)	101626.81 (0.03)	7.3	17	29(6,23)-29(5,24)	121018.36 (0.19)	20.9	200	12(1,12)-11(0,11)	132436.06 (0.03)	10.4	29
24(5,19)-24(4,20)	101728.59 (0.10)	17.5	138	11(0,11)-10(1,10)	121129.61 (0.03)	9.3	25	19(5,15)-19(4,16)	132503.10 (0.05)	10.6	90
26(6,20)-26(5,21)	101839.61 (0.10)	20.8	164	11(5, 6)-11(4, 7)	121161.69 (0.06)	5.6	39	30(6,24)-30(5,25)	132814.52 (0.25)	20.3	213
16(5,11)-16(4,12)	102734.12 (0.05)	10.1	68	11(1,11)-10(1,10)	121460.19 (0.03)	10.8	25	11(1,10)-10(1, 9)	132921.90 (0.03)	10.6	28
21(4,17)-21(3,18)	103057.04 (0.09)	13.3	105	11(0,11)-10(0,10)	121693.68 (0.03)	10.8	25	17(3,15)-17(2,16)	134497.43 (0.05)	5.9	66
13(4,10)-13(3,11)	103228.39 (0.03)	7.1	45	11(1,11)-10(0,10)	122024.26 (0.03)	9.4	25	11(10, 1)-10(10, 0)	134981.15 (0.05)	1.9	73
24(6,18)-24(5,19)	103387.06 (0.09)	18.4	142	17(4,14)-17(3,15)	122180.05 (0.05)	8.5	70	11(10, 2)-10(10, 1)	134995.41 (0.05)	1.9	73
8(2, 6)- 7(2, 5)	103466.59 (0.03)	7.5	17	28(7,21)-28(6,22)	122437.41 (0.19)	20.7	192	11(9, 2)-10(9, 1)	135046.33 (0.05)	3.6	64
27(6,21)-27(5,22)	105280.78 (0.12)	21.3	175	10(1, 9)- 9(1, 8)	122450.81 (0.03)	9.7	24	11(9, 3)-10(9, 2)	135060.33 (0.05)	3.6	64
15(2,13)-15(1,14)	105363.87 (0.06)	6.0	53	10(5, 5)-10(4, 6)	122506.02 (0.05)	4.8	34	11(3, 9)-10(3, 8)	135091.83 (0.03)	10.2	31
18(3,15)-18(2,16)	105459.14 (0.07)	9.4	77	13(5, 9)-18(4,10)	122519.16 (0.04)	7.0	49	11(8, 3)-10(8, 2)	135142.96 (0.04)	5.2	57
14(4,11)-14(3,12)	106632.81 (0.03)	7.6	51	12(5, 8)-12(4, 9)	122610.20 (0.05)	6.3	44	11(8, 4)-10(8, 3)	135156.42 (0.04)	5.2	57
9(2, 8)- 8(2, 7)	107537.26 (0.03)	8.5	20	14(5,10)-14(4,11)	122703.85 (0.04)	7.7	55	11(7, 4)-10(7, 3)	135290.42 (0.04)	6.6	50
23(6,17)-23(5,18)	107604.29 (0.08)	16.7	131	10(9, 1)- 9(9, 0)	122713.36 (0.05)	1.9	60	11(7, 5)-10(7, 4)	135303.12 (0.04)	6.6	50
15(5,10)-15(4,11)	108045.82 (0.05)	8.9	61	10(9, 2)- 9(9, 1)	122726.21 (0.05)	1.9	60	11(6, 5)-10(6, 4)	135527.09 (0.04)	7.7	44
22(4,18)-22(4,19)	108539.62 (0.11)	0.9	115	10(8, 2)- 9(8, 1)	122784.61 (0.04)	3.6	52	11(6, 6)-10(6, 5)	135538.89 (0.04)	7.7	44
14(3,12)-14(2,13)	108834.94 (0.04)	5.8	47	10(8, 3)- 9(8, 2)	122796.95 (0.04)	3.6	52	26(7,19)-26(6,20)	135693.69 (0.15)	17.4	168
10(1, 9)- 9(2, 8)	109292.39 (0.04)	4.7	24	11(5, 7)-11(4, 8)	122862.91 (0.05)	5.5	39	11(5, 7)-10(5, 6)	135943.09 (0.03)	8.7	39
10(0,10)- 9(1, 9)	110224.58 (0.03)	8.3	21	10(7, 3)- 9(7, 2)	122894.09 (0.04)	5.1	45	11(5, 6)-10(5, 5)	135948.89 (0.03)	8.7	39
9(8, 1)- 8(8, 0)	110447.05 (0.04)	1.9	48	10(7, 4)- 9(7, 3)	122905.69 (0.04)	5.1	45	11(4, 8)-10(4, 7)	136280.03 (0.03)	9.5	35
9(8, 2)- 8(8, 1)	110458.22 (0.04)	1.9	48	10(3, 8)- 9(3, 7)	123051.45 (0.03)	9.1	27	12(1,11)-11(2,10)	136590.34 (0.03)	6.9	33
9(7, 2)- 8(7, 1)	110525.66 (0.04)	3.6	41	10(6, 4)- 9(6, 3)	123070.21 (0.04)	6.4	39	19(4,16)-19(3,17)	136662.16 (0.05)	8.8	86
9(7, 3)- 8(7, 2)	110536.15 (0.04)	3.6	41	9(5, 5)- 9(4, 5)	123071.20 (0.08)	0.9	30	20(5,16)-20(4,17)	136953.76 (0.06)	11.0	98
9(6, 3)- 8(6, 2)	110652.76 (0.03)	5.0	35	10(6, 5)- 9(6, 4)	123080.94 (0.04)	6.4	39	11(4, 7)-10(4, 6)	137293.22 (0.03)	9.5	35
9(6, 4)- 8(6, 3)	110662.41 (0.03)	5.0	35	10(5, 6)-10(4, 7)	123199.85 (0.05)	4.8	34	18(6,12)-18(5,13)	137307.86 (0.06)	10.3	87

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TABLE 3—*Continued*

ASSIGNMENT	FREQUENCY	S	E
27(5,22)-27(4,23)	138665.74 (0.14)	16.0	172
11(2,10)-10(1, 9)	139565.72 (0.03)	6.0	28
18(2,16)-18(1,17)	140047.36 (0.05)	6.0	73
24(4,20)-24(4,21)	140113.36 (0.10)	0.9	135
12(2,11)-11(2,10)	141037.69 (0.03)	11.6	33
11(3, 8)-10(3, 7)	141244.02 (0.03)	10.2	32
17(6,11)-17(5,12)	141354.23 (0.06)	9.5	80
11(2, 9)-10(2, 8)	141653.05 (0.03)	10.6	30
21(5,17)-21(4,18)	142326.49 (0.06)	11.3	107
13(0,13)-12(1,12)	142624.48 (0.03)	11.4	34
13(1,13)-12(1,12)	142733.50 (0.03)	12.8	34
13(0,13)-12(0,12)	142815.44 (0.03)	12.8	34
13(1,13)-12(0,12)	142924.46 (0.03)	11.4	34
25(7,18)-25(6,19)	143218.65 (0.13)	15.9	157
12(1,11)-11(1,10)	143234.16 (0.03)	11.6	33
24(4,20)-24(3,21)	143303.10 (0.09)	12.3	135
18(3,16)-18(2,17)	143784.05 (0.05)	5.9	74
21(3,18)-21(2,19)	143997.30 (0.06)	9.0	102
16(6,10)-16(5,11)	144448.55 (0.07)	8.7	73
20(4,17)-20(3,18)	144886.55 (0.05)	8.9	94
15(6, 9)-15(5,10)	146747.96 (0.08)	7.9	66
12(3,10)-11(3, 9)	146977.67 (0.03)	11.2	36
18(6,13)-18(5,14)	147248.20 (0.05)	10.1	87
12(11, 1)-11(11, 0)	147250.42 (0.05)	1.9	88
12(11, 2)-11(11, 1)	147265.76 (0.05)	1.9	88
5(5, 1)- 6(3, 4)	147266.59 (0.12)	0.0	18
19(6,14)-19(5,15)	147305.00 (0.05)	10.8	95
12(10, 2)-11(10, 1)	147310.32 (0.05)	3.7	78
12(10, 3)-11(10, 2)	147325.73 (0.05)	3.7	78
12(9, 3)-11(9, 2)	147396.92 (0.05)	5.3	69
12(9, 4)-11(9, 3)	147412.05 (0.05)	5.3	69
12(8, 4)-11(8, 3)	147524.22 (0.04)	6.7	61
12(8, 5)-11(8, 4)	147538.79 (0.04)	6.7	61
17(6,12)-17(5,13)	147539.60 (0.06)	9.4	80
28(5,23)-28(5,24)	147642.35 (0.19)	1.0	184
12(2,11)-11(1,10)	147681.51 (0.03)	7.0	33
12(7, 5)-11(7, 4)	147717.65 (0.04)	7.9	55
12(7, 6)-11(7, 5)	147731.43 (0.04)	7.9	55
20(6,15)-20(5,16)	147852.06 (0.06)	11.5	103
12(6, 6)-11(6, 5)	148028.03 (0.04)	9.0	49
12(6, 7)-11(6, 6)	148040.79 (0.04)	9.0	49
16(6,11)-16(5,12)	148044.74 (0.07)	8.6	73
14(6, 8)-14(5, 9)	148418.91 (0.07)	7.1	60
12(5, 8)-11(5, 7)	148545.06 (0.04)	9.9	44
22(5,18)-22(4,19)	148585.77 (0.06)	11.6	116
12(5, 7)-11(5, 6)	148614.80 (0.04)	9.9	44
15(6,10)-15(5,11)	148653.95 (0.08)	7.9	66
12(4, 9)-11(4, 8)	148797.77 (0.03)	10.7	40
21(6,16)-21(5,17)	149028.01 (0.06)	12.2	112
13(1,12)-12(2,11)	149065.31 (0.03)	8.0	38
14(6, 9)-14(5,10)	149296.46 (0.07)	7.1	60
13(6, 7)-13(5, 8)	149611.32 (0.06)	6.4	54
13(6, 8)-13(5, 9)	149924.42 (0.06)	6.4	54
24(7,17)-24(6,18)	150399.60 (0.11)	14.7	147
12(6, 6)-12(5, 7)	150449.24 (0.05)	5.7	49
12(6, 7)-12(5, 8)	150504.47 (0.05)	5.7	49
12(4, 8)-11(4, 7)	150600.78 (0.03)	10.7	40
19(2,17)-19(1,18)	150855.99 (0.05)	6.0	81
22(6,17)-22(5,18)	150957.25 (0.07)	12.8	121
11(6, 6)-11(5, 7)	151008.75 (0.05)	4.9	44
8(4, 5)- 8(2, 6)	151009.19 (0.08)	0.0	22
11(6, 5)-11(5, 6)	151036.02 (0.05)	4.9	44
13(2,12)-12(2,11)	151950.04 (0.03)	12.6	38
14(2,12)-13(3,11)	152780.28 (0.05)	5.0	47
28(5,23)-28(4,24)	153226.20 (0.16)	15.6	184
19(3,17)-19(2,18)	153283.10 (0.05)	6.0	81
14(0,14)-13(1,13)	153288.82 (0.03)	12.4	39
14(1,14)-13(1,13)	153350.44 (0.03)	13.8	39
14(0,14)-13(0,13)	153397.83 (0.03)	13.8	39
14(1,14)-13(0,13)	153459.45 (0.03)	12.4	39
13(1,12)-12(1,11)	153512.66 (0.03)	12.6	38
12(2,10)-11(2, 9)	153553.25 (0.03)	11.6	35
21(4,18)-21(3,19)	153618.57 (0.05)	8.9	102
23(6,18)-23(5,19)	153739.76 (0.07)	13.3	131
25(4,21)-25(4,22)	154891.70 (0.09)	0.9	145
12(3, 9)-11(3, 8)	154984.54 (0.04)	11.3	37
23(5,19)-23(4,20)	155663.04 (0.06)	11.7	126
22(3,19)-22(2,20)	156090.30 (0.05)	9.0	111
13(2,12)-12(1,11)	156397.39 (0.03)	8.1	38
23(7,16)-23(6,17)	156758.64 (0.09)	13.7	137
25(4,21)-25(3,22)	156946.49 (0.08)	12.2	145
24(6,19)-24(5,20)	157442.96 (0.08)	13.8	141
13(3,11)-12(3,10)	158693.69 (0.03)	12.2	41
30(8,22)-30(7,23)	159117.76 (0.33)	19.6	222
13(12, 1)-12(12, 0)	159521.22 (0.06)	1.9	104
13(12, 2)-12(12, 1)	159537.21 (0.06)	1.9	104
13(11, 2)-12(11, 1)	159576.34 (0.05)	3.7	93
13(6, 8)-14(3,11)	159591.35 (0.14)	0.0	54
13(11, 3)-12(11, 2)	159592.78 (0.05)	3.7	93
13(10, 3)-12(10, 2)	159654.66 (0.05)	5.3	83
13(10, 4)-12(10, 3)	159671.17 (0.05)	5.3	83
13(9, 4)-12(9, 3)	159766.76 (0.05)	6.8	75
13(9, 5)-12(9, 4)	159782.99 (0.05)	6.8	75
13(8, 5)-12(8, 4)	159930.59 (0.04)	8.1	67
13(8, 6)-12(8, 5)	159946.24 (0.04)	8.1	67
13(7, 6)-12(7, 5)	160178.87 (0.04)	9.2	60
13(7, 7)-12(7, 6)	160193.72 (0.04)	9.2	60
23(5,19)-23(3,20)	160531.59 (0.06)	0.8	126
13(6, 7)-12(6, 6)	160578.28 (0.04)	10.2	54
13(6, 8)-12(6, 7)	160591.33 (0.04)	10.2	54
14(1,13)-13(2,12)	160944.89 (0.03)	9.0	43
13(5, 9)-12(5, 8)	161171.38 (0.04)	11.1	49
13(4,10)-12(4, 9)	161262.43 (0.03)	11.8	45
20(2,18)-20(1,19)	161380.29 (0.05)	6.0	89
13(5, 8)-12(5, 7)	161416.21 (0.04)	11.1	49
22(7,15)-22(6,16)	162063.29 (0.08)	12.7	127
25(6,20)-25(5,21)	162096.60 (0.08)	14.2	151
22(4,19)-22(3,20)	162747.61 (0.04)	8.9	111
14(2,13)-13(2,12)	162768.81 (0.03)	13.6	43
20(3,18)-20(2,19)	162925.96 (0.05)	6.0	89
24(5,20)-24(4,21)	163464.51 (0.06)	11.8	136
14(1,13)-13(1,12)	163829.61 (0.03)	13.6	43
15(0,15)-14(1,14)	163925.81 (0.03)	13.4	45
15(1,15)-14(1,14)	163960.35 (0.03)	14.8	45
15(0,15)-14(0,14)	163987.43 (0.03)	14.8	45
15(1,15)-14(0,14)	164021.97 (0.03)	13.4	45
29(5,24)-29(5,25)	164151.66 (0.20)	1.1	196
13(4, 9)-12(4, 8)	164205.95 (0.04)	11.8	45
13(2,11)-12(2,10)	164955.70 (0.03)	12.5	41
14(2,13)-13(1,12)	165653.53 (0.03)	9.1	43
21(7,14)-21(6,15)	166297.11 (0.07)	11.8	118
24(5,20)-24(3,21)	166654.25 (0.06)	0.8	136
29(8,21)-29(7,22)	167392.57 (0.26)	18.2	210
23(3,20)-23(2,21)	167685.27 (0.05)	9.0	120
26(6,21)-26(5,22)	167691.39 (0.08)	14.4	162
29(5,24)-29(4,25)	167850.76 (0.17)	15.4	196
13(3,10)-12(3, 9)	168495.08 (0.03)	12.4	43
26(4,22)-26(4,23)	168788.36 (0.08)	0.9	156
15(2,13)-14(3,12)	168914.76 (0.04)	6.1	53
20(7,13)-20(6,14)	169584.06 (0.09)	11.0	109
26(4,22)-26(3,23)	170093.13 (0.07)	12.1	156
14(3,12)-13(3,11)	170233.24 (0.03)	13.3	47
24(7,18)-24(6,19)	171027.07 (0.08)	14.0	147
23(7,17)-23(6,18)	171052.80 (0.07)	13.3	137
22(7,16)-22(6,17)	171499.15 (0.07)	12.5	127
25(7,19)-25(6,20)	171562.90 (0.09)	14.7	157
21(2,19)-21(1,20)	171692.25 (0.05)	6.0	97
14(13, 1)-13(13, 0)	171793.63 (0.07)	1.9	121
14(13, 2)-13(13, 1)	171809.74 (0.07)	1.9	121
14(12, 2)-13(12, 1)	171844.27 (0.05)	3.7	109
14(12, 3)-13(12, 2)	171861.29 (0.05)	3.7	109
25(5,21)-25(4,22)	171880.82 (0.05)	11.9	146
14(11, 3)-13(11, 2)	171915.45 (0.05)	5.4	99
14(11, 4)-13(11, 3)	171932.95 (0.05)	5.4	99
14(10, 4)-13(10, 3)	172015.44 (0.05)	6.9	89
14(10, 5)-13(10, 4)	172033.02 (0.05)	6.9	89
19(7,12)-19(6,13)	172103.89 (0.11)	10.2	101
14(9, 5)-13(9, 4)	172157.52 (0.05)	8.2	80
23(4,20)-23(3,21)	172172.88 (0.04)	9.0	121
14(9, 6)-13(9, 5)	172174.81 (0.05)	8.2	80
21(7,15)-21(6,16)	172228.93 (0.07)	11.7	118
14(8, 6)-13(8, 5)	172364.32 (0.04)	9.4	73
14(8, 7)-13(8, 6)	172381.01 (0.04)	9.4	73
15(1,14)-14(2,13)	172385.83 (0.03)	10.1	49
21(3,19)-21(2,20)	172660.55 (0.05)	6.0	97
14(7, 7)-13(7, 6)	172677.38 (0.04)	10.5	66
14(7, 8)-13(7, 7)	172693.27 (0.04)	10.5	66
26(7,20)-26(6,21)	172794.71 (0.10)	15.4	168
20(7,14)-20(6,15)	173117.23 (0.09)	11.0	109
14(6, 8)-13(6, 7)	173185.08 (0.04)	11.4	60
14(6, 9)-13(6, 8)	173194.40 (0.04)	11.4	60
15(2,14)-14(2,13)	173515.38 (0.03)	14.6	49

TABLE 3—*Continued*

ASSIGNMENT	FREQUENCY	S	E	ASSIGNMENT	FREQUENCY	S	E	ASSIGNMENT	FREQUENCY	S	E
14(4,11)-13(4,10)	173637.66 (0.03)	12.8	51	15(13, 2)-14(13, 1)	184114.07 (0.06)	3.7	127	24(8,16)-24(7,17)	194622.16 (0.10)	13.4	153
14(5,10)-13(5, 9)	173822.35 (0.03)	12.2	55	15(13, 3)-14(13, 2)	184131.12 (0.06)	3.7	127	30(8,23)-30(7,24)	194623.41 (0.21)	18.0	222
25(5,21)-25(3,22)	173935.61 (0.06)	0.9	146	15(12, 3)-14(12, 2)	184178.89 (0.05)	5.4	116	27(8,20)-27(7,21)	194681.32 (0.12)	15.7	186
18(7,11)-18(6,12)	174024.62 (0.11)	9.5	93	15(12, 4)-14(12, 3)	184196.89 (0.05)	5.4	116	17(2,16)-16(2,15)	194864.97 (0.03)	16.6	62
19(7,13)-19(6,14)	174061.68 (0.11)	10.2	101	16(2,15)-15(2,14)	184208.87 (0.03)	15.6	55	17(1,16)-16(1,15)	195139.85 (0.03)	16.6	62
27(6,22)-27(5,23)	174181.30 (0.09)	14.7	173	15(11, 4)-14(11, 3)	184268.79 (0.05)	6.9	105	17(2,16)-16(1,15)	195552.71 (0.03)	12.2	62
15(1,14)-14(1,13)	174209.75 (0.03)	14.6	49	15(11, 5)-14(11, 4)	184287.29 (0.05)	6.9	105	26(8,19)-26(7,20)	195588.10 (0.10)	14.9	174
14(5, 9)-13(5, 8)	174377.49 (0.04)	12.2	55	15(10, 5)-14(10, 4)	184393.98 (0.05)	8.3	95	18(0,18)-17(1,17)	195762.77 (0.03)	16.4	63
16(0,16)-15(1,15)	174546.56 (0.03)	14.4	51	15(10, 6)-14(10, 5)	184412.56 (0.05)	8.3	95	18(1,18)-17(1,17)	195768.61 (0.03)	17.8	63
16(1,16)-15(1,15)	174565.78 (0.03)	15.8	51	15(9, 6)-14(9, 5)	184570.90 (0.04)	9.6	87	18(0,18)-17(0,17)	195773.39 (0.03)	17.8	63
16(0,16)-15(0,15)	174581.10 (0.03)	15.8	51	15(9, 7)-14(9, 6)	184589.20 (0.04)	9.6	87	18(1,18)-17(0,17)	195779.23 (0.03)	16.4	63
17(3,14)-16(4,13)	174593.32 (0.07)	4.3	69	16(1,15)-15(1,14)	184650.68 (0.03)	15.6	55	16(15, 1)-15(15, 0)	196343.54 (0.11)	1.9	159
16(1,16)-15(0,15)	174600.32 (0.03)	14.4	51	15(8, 7)-14(8, 6)	184827.73 (0.04)	10.7	79	16(15, 2)-15(15, 1)	196358.03 (0.11)	1.9	159
27(7,21)-27(6,22)	174839.61 (0.12)	16.0	179	15(8, 8)-14(8, 7)	184845.44 (0.04)	10.7	79	16(14, 2)-15(14, 1)	196385.74 (0.08)	3.8	146
28(8,20)-28(7,21)	174973.07 (0.21)	17.1	197	17(0,17)-16(1,16)	185157.61 (0.03)	15.4	57	16(14, 3)-15(14, 2)	196402.19 (0.08)	3.8	146
18(7,12)-18(6,13)	174996.07 (0.11)	9.4	93	17(1,17)-16(1,16)	185168.24 (0.03)	16.8	57	16(13, 3)-15(13, 2)	196444.72 (0.06)	5.4	134
15(2,14)-14(1,13)	175339.30 (0.03)	10.1	49	17(0,17)-16(0,16)	185176.83 (0.03)	16.8	57	16(13, 4)-15(13, 3)	196462.65 (0.06)	5.4	134
17(7,10)-17(6,11)	175482.18 (0.09)	8.7	85	21(17, 5)-22(16, 6)	185178.13 (1.38)	0.4	228	16(12, 4)-15(12, 3)	196525.91 (0.05)	7.0	122
14(2,12)-13(2,11)	175867.59 (0.03)	13.5	47	17(1,17)-16(0,16)	185187.46 (0.03)	15.4	57	16(12, 5)-15(12, 4)	196544.84 (0.05)	7.0	122
17(7,11)-17(6,12)	175882.61 (0.09)	8.7	85	15(7, 8)-14(7, 7)	185216.69 (0.04)	11.7	72	16(2,14)-15(2,13)	196596.81 (0.03)	15.4	59
16(7, 9)-16(6,10)	176585.24 (0.06)	8.0	78	15(7, 9)-14(7, 8)	185233.59 (0.04)	11.7	72	16(11, 5)-15(11, 4)	196637.38 (0.05)	8.4	112
16(7,10)-16(6,11)	176697.03 (0.06)	8.0	78	16(2,15)-15(1,14)	185338.42 (0.03)	11.2	55	16(11, 6)-15(11, 5)	196656.84 (0.05)	8.4	112
15(7, 8)-15(6, 9)	177421.25 (0.05)	7.2	72	5(5, 1)- 4(4, 0)	185629.08 (0.12)	4.5	18	25(8,18)-25(7,19)	196716.58 (0.09)	14.1	164
15(7, 9)-15(6,10)	177421.56 (0.05)	7.2	72	15(6,10)-14(6, 9)	185849.02 (0.04)	12.6	66	16(10, 6)-15(10, 5)	196791.57 (0.04)	9.8	102
28(7,22)-28(6,23)	177787.69 (0.14)	16.5	191	15(6, 9)-14(6, 8)	185862.13 (0.04)	12.6	66	16(10, 7)-15(10, 6)	196811.13 (0.04)	9.8	102
14(7, 8)-14(6, 9)	178036.99 (0.05)	6.5	66	15(4,12)-14(4,11)	185889.88 (0.03)	13.9	57	16(9, 7)-15(9, 6)	197008.65 (0.04)	10.9	93
14(7, 7)-14(6, 8)	178066.69 (0.05)	6.5	66	5(5, 0)- 4(4, 1)	186239.16 (0.12)	4.5	18	16(9, 8)-15(9, 7)	197027.92 (0.04)	10.9	93
14(4,10)-13(4, 9)	178090.91 (0.04)	12.9	51	15(2,13)-14(2,12)	186367.72 (0.03)	14.4	53	23(8,15)-23(7,16)	197293.93 (0.13)	12.6	143
13(7, 7)-13(6, 8)	178538.12 (0.05)	5.8	60	15(5,11)-14(5,10)	186491.53 (0.03)	13.3	61	16(8, 8)-15(8, 7)	197323.29 (0.04)	12.0	85
13(7, 6)-13(6, 7)	178574.39 (0.05)	5.8	60	30(7,24)-30(6,25)	186578.49 (0.18)	17.3	215	16(8, 9)-15(8, 8)	197341.98 (0.04)	12.0	85
26(19, 7)-27(18,10)	178575.24 (2.53)	0.7	310	26(8,18)-26(7,19)	186907.42 (0.12)	15.1	174	16(7, 9)-15(7, 8)	197800.76 (0.04)	12.9	78
24(3,21)-24(3,22)	178618.51 (0.04)	0.8	130	15(5,10)-14(5, 9)	187533.09 (0.03)	13.3	61	16(7,10)-15(7, 9)	197818.40 (0.04)	12.9	78
24(3,21)-24(2,22)	178848.06 (0.04)	9.0	130	13(3,11)-12(2,10)	188043.02 (0.04)	4.9	41	17(2,15)-16(3,14)	197824.34 (0.03)	8.4	66
12(7, 6)-12(6, 7)	178935.74 (0.05)	5.0	55	29(6,24)-29(5,25)	189515.00 (0.10)	14.9	197	6(5, 2)- 5(4, 1)	197892.01 (0.11)	4.5	20
12(7, 5)-12(6, 6)	178973.80 (0.05)	5.0	55	25(3,22)-25(3,23)	189529.43 (0.04)	0.8	140	20(17, 3)-21(16, 6)	197893.33 (1.42)	0.3	219
30(5,25)-30(5,26)	179685.09 (0.20)	1.1	209	25(3,22)-25(2,23)	189666.54 (0.04)	9.0	140	24(8,17)-24(7,18)	197953.65 (0.09)	13.3	153
26(5,22)-26(4,23)	180797.08 (0.05)	11.9	156	27(5,23)-27(4,24)	190101.98 (0.05)	12.0	167	16(4,13)-15(4,12)	197990.61 (0.03)	15.0	63
28(6,23)-28(5,24)	181489.18 (0.09)	14.8	185	27(5,23)-27(3,24)	190920.29 (0.05)	0.9	167	30(6,25)-30(5,26)	198145.53 (0.11)	15.0	209
27(8,19)-27(7,20)	181513.73 (0.16)	16.0	186	25(8,17)-25(7,18)	191222.75 (0.10)	14.2	164	6(5, 1)- 5(4, 2)	198492.31 (0.11)	4.5	20
15(3,13)-14(3,12)	181598.43 (0.03)	14.3	53	21(1,20)-21(1,21)	191439.03 (0.07)	0.3	91	16(6,11)-15(6,10)	198542.93 (0.04)	13.8	73
14(3,11)-13(3,10)	181654.14 (0.03)	13.4	49	21(1,20)-21(0,21)	191439.97 (0.07)	3.0	91	16(6,10)-15(6, 9)	198636.77 (0.04)	13.8	73
20(1,19)-20(1,20)	181655.09 (0.07)	0.3	84	25(4,22)-25(3,23)	191584.22 (0.04)	9.0	140	15(3,13)-14(2,12)	199051.38 (0.04)	6.6	53
29(7,23)-29(6,24)	181694.79 (0.16)	17.0	203	23(2,21)-23(1,22)	191900.91 (0.04)	6.0	115	16(5,12)-15(5,11)	199152.15 (0.03)	14.4	68
24(4,21)-24(3,22)	181808.25 (0.04)	9.0	130	15(4,11)-14(4,10)	192159.81 (0.04)	14.0	57	23(8,16)-23(7,17)	199206.74 (0.13)	12.6	143
27(4,23)-27(4,24)	181824.86 (0.07)	0.9	167	23(3,21)-23(2,22)	192266.10 (0.04)	6.0	115	22(8,14)-22(7,15)	199404.66 (0.14)	11.8	134
22(2,20)-22(1,21)	181851.00 (0.05)	6.0	106	16(3,14)-15(3,13)	192799.58 (0.03)	15.3	60	28(5,24)-28(4,25)	199694.79 (0.05)	12.0	179
30(5,25)-30(4,26)	182098.04 (0.18)	15.2	209	14(3,12)-13(2,11)	193320.55 (0.04)	5.7	47	26(3,23)-26(3,24)	200142.87 (0.05)	0.8	150
26(5,22)-26(3,23)	182101.85 (0.05)	0.9	156	29(8,22)-29(7,23)	194059.60 (0.18)	17.3	209	28(5,24)-28(3,25)	200202.48 (0.06)	1.0	179
22(3,20)-22(2,21)	182449.22 (0.05)	6.0	106	18(3,15)-17(4,14)	194079.84 (0.06)	5.3	77	26(3,23)-26(2,24)	200224.11 (0.05)	9.0	150
27(4,23)-27(3,24)	182643.17 (0.07)	12.0	167	28(4,24)-28(4,25)	194110.94 (0.07)	1.0	179	22(8,15)-22(7,16)	200412.38 (0.14)	11.8	134
16(1,15)-15(2,14)	183521.12 (0.03)	11.2	55	28(8,21)-28(7,22)	194125.48 (0.15)	16.5	197	16(5,11)-15(5,10)	200936.17 (0.03)	14.4	68
16(2,14)-15(3,13)	183913.15 (0.04)	7.3	59	15(3,12)-14(3,11)	194377.23 (0.03)	14.4	55	21(8,13)-21(7,14)	201078.85 (0.12)	11.0	125
15(14, 1)-14(14, 0)	184067.71 (0.09)	1.9	140	17(1,16)-16(2,15)	194452.11 (0.03)	12.2	62	22(1,21)-22(1,22)	201205.39 (0.07)	0.3	100
15(14, 2)-14(14, 1)	184083.35 (0.09)	1.9	140	28(4,24)-28(3,25)	194618.62 (0.07)	12.0	179	22(1,21)-22(0,22)	201205.89 (0.07)	3.0	100

TABLE 3—*Continued*

ASSIGNMENT	FREQUENCY	S	E
26(4,23)-26(3,24)	201447.64 (0.05)	9.0	150
21(8,14)-21(7,15)	201539.16 (0.12)	11.0	125
24(2,22)-24(1,23)	201873.55 (0.04)	6.0	124
24(3,22)-24(2,23)	202094.18 (0.04)	6.0	124
20(8,12)-20(7,13)	202410.34 (0.09)	10.3	116
20(8,13)-20(7,14)	202571.58 (0.09)	10.3	116
19(8,11)-19(7,12)	203472.38 (0.06)	9.5	108
19(8,12)-19(7,13)	203500.81 (0.06)	9.5	108
17(3,15)-16(3,14)	203853.71 (0.03)	16.3	66
18(8,11)-18(7,12)	204315.54 (0.05)	8.8	100
18(8,10)-18(7,11)	204329.38 (0.05)	8.8	100
17(8,10)-17(7,11)	205008.65 (0.05)	8.0	92
17(8, 9)-17(7,10)	205032.82 (0.05)	8.0	92
30(7,24)-30(5,25)	205038.94 (0.29)	0.8	215
18(1,17)-17(2,16)	205250.81 (0.03)	13.2	69
16(3,14)-15(2,13)	205483.24 (0.04)	7.6	60
18(2,17)-17(2,16)	205495.69 (0.03)	17.6	69
16(8, 9)-16(7,10)	205586.88 (0.05)	7.3	85
16(8, 8)-16(7, 9)	205613.59 (0.05)	7.3	85
18(1,17)-17(1,16)	205663.66 (0.03)	17.6	69
29(4,25)-29(4,26)	205790.57 (0.08)	1.0	190
18(2,17)-17(1,16)	205908.55 (0.03)	13.2	69
15(8, 8)-15(7, 9)	206063.30 (0.05)	6.6	79
15(8, 7)-15(7, 8)	206091.06 (0.05)	6.6	79
29(4,25)-29(3,26)	206102.54 (0.08)	12.0	190
16(4,12)-15(4,11)	206247.88 (0.03)	15.1	64
19(0,19)-18(1,18)	206364.18 (0.03)	17.4	70
19(1,19)-18(1,18)	206367.38 (0.03)	18.8	70
19(0,19)-18(0,18)	206370.03 (0.03)	18.8	70
19(1,19)-18(0,18)	206373.22 (0.03)	17.4	70
14(8, 7)-14(7, 8)	206451.45 (0.05)	5.8	73
14(8, 6)-14(7, 7)	206480.02 (0.05)	5.8	73
16(3,13)-15(3,12)	206601.17 (0.03)	15.4	62
17(2,15)-16(2,14)	206710.77 (0.03)	16.4	66
13(8, 6)-13(7, 7)	206763.71 (0.05)	5.1	67
13(8, 5)-13(7, 6)	206793.09 (0.05)	5.1	67
12(8, 5)-12(7, 6)	207011.19 (0.05)	4.4	61
12(8, 4)-12(7, 5)	207041.37 (0.05)	4.4	61
17(16, 1)-16(16, 0)	208621.22 (0.14)	1.9	181
17(16, 2)-16(16, 1)	208633.81 (0.14)	1.9	181
17(15, 2)-16(15, 1)	208659.30 (0.10)	3.8	166
17(15, 3)-16(15, 2)	208674.45 (0.10)	3.8	166
17(14, 3)-16(14, 2)	208712.80 (0.07)	5.5	153
17(14, 4)-16(14, 3)	208730.00 (0.07)	5.5	153
17(13, 4)-16(13, 3)	208786.25 (0.05)	7.1	141
17(13, 5)-16(13, 4)	208805.00 (0.05)	7.1	141
17(12, 5)-16(12, 4)	208886.17 (0.05)	8.5	129
17(12, 6)-16(12, 5)	208905.96 (0.05)	8.5	129
17(11, 6)-16(11, 5)	209022.27 (0.04)	9.9	119
17(11, 7)-16(11, 6)	209042.62 (0.04)	9.9	119
17(10, 7)-16(10, 6)	209209.58 (0.04)	11.1	109
17(10, 8)-16(10, 7)	209230.05 (0.04)	11.1	109
17(9, 8)-16(9, 7)	209472.56 (0.04)	12.2	100
29(5,25)-29(4,26)	209489.66 (0.07)	12.0	191
17(9, 9)-16(9, 8)	209492.76 (0.04)	12.2	100
29(5,25)-29(3,26)	209801.64 (0.07)	1.0	191
17(8, 9)-16(8, 8)	209853.60 (0.04)	13.2	92
17(8,10)-16(8, 9)	209873.24 (0.04)	13.2	92
17(4,14)-16(4,13)	209918.46 (0.03)	16.0	70
7(5, 3)- 6(4, 2)	210136.82 (0.11)	4.5	23
17(7,10)-16(7, 9)	210434.38 (0.04)	14.1	85
17(7,11)-16(7,10)	210451.46 (0.04)	14.1	85
27(3,24)-27(3,25)	210541.49 (0.05)	0.8	161
27(3,24)-27(2,25)	210589.29 (0.05)	9.0	161
7(5, 2)- 6(4, 3)	210725.80 (0.11)	4.5	23
18(2,16)-17(3,15)	210800.74 (0.03)	9.6	73
23(1,22)-23(1,23)	210958.55 (0.07)	0.3	108
23(1,22)-23(0,23)	210958.82 (0.07)	3.0	108
21(4,17)-20(5,16)	211241.57 (0.09)	4.6	105
17(6,12)-16(6,11)	211265.88 (0.04)	14.9	80
27(4,24)-27(3,25)	211359.79 (0.05)	9.0	161
17(6,11)-16(6,10)	211537.44 (0.04)	14.9	80
17(5,13)-16(5,12)	211771.02 (0.03)	15.5	75
25(2,23)-25(1,24)	211790.75 (0.04)	6.0	134
30(9,21)-30(8,22)	211810.35 (0.24)	17.5	229
25(3,23)-25(2,24)	211922.83 (0.04)	6.0	134
19(3,16)-18(4,15)	212440.45 (0.05)	6.4	85
17(3,15)-16(2,14)	212740.14 (0.04)	8.6	66
17(5,12)-16(5,11)	214631.75 (0.03)	15.5	75
18(3,16)-17(3,15)	214782.32 (0.03)	17.3	74
19(1,18)-18(2,17)	215965.97 (0.03)	14.2	76
19(2,18)-18(2,17)	216109.73 (0.03)	18.6	76
29(9,20)-29(8,21)	216134.54 (0.18)	16.6	217
19(1,18)-18(1,17)	216210.86 (0.03)	18.6	76
19(2,18)-18(1,17)	216354.62 (0.03)	14.2	76
18(2,16)-17(2,15)	216830.11 (0.03)	17.3	73
20(0,20)-19(1,19)	216963.05 (0.03)	18.4	77
20(1,20)-19(1,19)	216964.79 (0.03)	19.8	77
20(0,20)-19(0,19)	216966.25 (0.03)	19.8	77
20(1,20)-19(0,19)	216967.98 (0.03)	18.4	77
30(4,26)-30(4,27)	217004.38 (0.09)	1.0	203
30(4,26)-30(3,27)	217194.46 (0.09)	12.0	203
17(3,14)-16(3,13)	218280.85 (0.03)	16.4	69
30(5,26)-30(4,27)	219417.33 (0.08)	12.0	203
28(9,19)-28(8,20)	219592.25 (0.14)	15.8	205
30(9,22)-30(8,23)	219599.99 (0.20)	17.4	229
30(5,26)-30(3,27)	219607.41 (0.08)	1.0	203
17(4,13)-16(4,12)	220166.85 (0.03)	16.1	72
24(1,23)-24(1,24)	220701.36 (0.07)	0.3	117
24(1,23)-24(0,24)	220701.49 (0.07)	3.0	117
28(3,25)-28(3,26)	220786.17 (0.07)	0.8	172
18(3,16)-17(2,15)	220811.69 (0.03)	9.7	74
28(3,25)-28(2,26)	220814.11 (0.07)	9.0	172
18(17, 1)-17(17, 0)	220900.84 (0.17)	1.9	203
18(17, 2)-17(17, 1)	220910.70 (0.17)	1.9	203
18(16, 2)-17(16, 1)	220934.82 (0.11)	3.8	188
18(16, 3)-17(16, 2)	220947.86 (0.11)	3.8	188
18(15, 3)-17(15, 2)	220983.08 (0.08)	5.5	174
18(15, 4)-17(15, 3)	220998.80 (0.08)	5.5	174
18(14, 4)-17(14, 3)	221049.47 (0.06)	7.1	160
18(14, 5)-17(14, 4)	221067.34 (0.06)	7.1	160
29(9,21)-29(8,22)	221086.08 (0.16)	16.6	217
18(13, 5)-17(13, 4)	221139.35 (0.05)	8.6	148
18(13, 6)-17(13, 5)	221158.84 (0.05)	8.6	148
18(12, 6)-17(12, 5)	221260.50 (0.04)	10.0	136
18(12, 7)-17(12, 6)	221281.09 (0.04)	10.0	136
28(4,25)-28(3,26)	221293.85 (0.07)	9.0	172
18(11, 7)-17(11, 6)	221424.52 (0.04)	11.3	126
18(11, 8)-17(11, 7)	221445.70 (0.04)	11.3	126
18(10, 8)-17(10, 7)	221649.39 (0.04)	12.5	116
18(4,15)-17(4,14)	221660.46 (0.03)	17.0	78
26(2,24)-26(1,25)	221667.35 (0.05)	6.0	144
18(10, 9)-17(10, 8)	221670.71 (0.04)	12.5	116
26(3,24)-26(2,25)	221745.78 (0.05)	6.0	144
18(9, 9)-17(9, 8)	221964.54 (0.04)	13.5	108
18(9,10)-17(9, 9)	221985.62 (0.04)	13.5	108
8(5, 4)- 7(4, 3)	222345.08 (0.10)	4.6	26
27(9,18)-27(8,19)	222367.29 (0.14)	15.0	193
18(8,10)-17(8, 9)	222421.46 (0.04)	14.5	100
18(8,11)-17(8,10)	222442.01 (0.04)	14.5	100
28(9,20)-28(8,21)	222635.15 (0.13)	15.7	205
8(5, 3)- 7(4, 4)	222925.73 (0.10)	4.6	26
19(2,17)-18(3,16)	223037.92 (0.03)	10.7	81
18(7,11)-17(7,10)	223124.89 (0.03)	15.3	93
18(7,12)-17(7,11)	223135.13 (0.03)	15.3	93
18(6,13)-17(6,12)	224021.67 (0.03)	16.0	87
27(9,19)-27(8,20)	224167.75 (0.14)	14.9	193
18(5,14)-17(5,13)	224313.08 (0.03)	16.6	82
18(6,12)-17(6,11)	224582.45 (0.03)	16.0	87
26(9,17)-26(8,18)	224619.52 (0.18)	14.2	182
6(6, 1)- 5(5, 0)	225523.06 (0.14)	5.5	25
19(3,17)-18(3,16)	225608.78 (0.03)	18.3	81
26(9,18)-26(8,19)	225624.59 (0.18)	14.1	182
6(6, 0)- 5(5, 1)	226232.89 (0.14)	5.5	25
25(9,16)-25(8,17)	226468.63 (0.18)	13.4	171
20(1,19)-19(2,18)	226629.40 (0.03)	15.3	84
20(2,19)-19(2,18)	226713.04 (0.03)	19.5	84
20(1,19)-19(1,18)	226773.17 (0.03)	19.5	84
20(2,19)-19(1,18)	226856.81 (0.03)	15.3	84
25(9,17)-25(8,18)	226973.14 (0.18)	13.4	171
19(2,17)-18(2,16)	227019.49 (0.03)	18.3	81
21(0,21)-20(1,20)	227560.02 (0.03)	19.4	85
21(1,21)-20(1,20)	227560.95 (0.03)	20.8	85
21(0,21)-20(0,20)	227561.75 (0.03)	20.8	85
21(1,21)-20(0,20)	227562.69 (0.03)	19.4	85
24(9,15)-24(8,16)	227995.54 (0.14)	12.6	161
24(9,16)-24(8,17)	228204.82 (0.14)	12.6	161
18(5,13)-17(5,12)	228628.82 (0.03)	16.6	83
23(9,14)-23(8,15)	229260.20 (0.08)	11.8	151
23(9,15)-23(8,16)	229319.19 (0.08)	11.8	151
18(3,15)-17(3,14)	229404.98 (0.03)	17.3	77
20(3,17)-19(4,16)	229474.17 (0.05)	7.5	93

TABLE 3—*Continued*

ASSIGNMENT	FREQUENCY	S	E
19(3,17)-18(2,16)	229590.35 (0.03)	10.8	81
22(9,13)-22(8,14)	230313.00 (0.05)	11.1	141
22(9,14)-22(8,15)	230315.11 (0.05)	11.1	141
25(1,24)-25(1,25)	230435.66 (0.08)	0.3	127
25(1,24)-25(0,25)	230435.73 (0.08)	3.0	127
29(3,26)-29(3,27)	230920.12 (0.09)	0.8	184
29(3,26)-29(2,27)	230936.36 (0.09)	9.0	184
21(9,13)-21(8,14)	231187.32 (0.05)	10.3	132
21(9,12)-21(8,13)	231200.54 (0.05)	10.3	132
29(4,26)-29(3,27)	231232.10 (0.09)	9.0	184
27(2,25)-27(1,26)	231513.38 (0.07)	6.0	154
27(3,25)-27(2,26)	231559.62 (0.07)	6.0	154
20(9,12)-20(8,13)	231938.57 (0.05)	9.6	124
20(9,11)-20(8,12)	231955.32 (0.05)	9.6	124
19(9,11)-19(8,12)	232579.47 (0.04)	8.9	115
19(9,10)-19(8,11)	232597.19 (0.04)	8.9	115
22(4,18)-21(5,17)	233032.49 (0.09)	5.5	115
18(9,10)-18(8,11)	233122.31 (0.04)	8.1	108
18(9, 9)-18(8,10)	233140.58 (0.04)	8.1	108
19(18, 1)-18(18, 0)	233182.54 (0.22)	1.9	227
19(18, 2)-18(18, 1)	233188.72 (0.22)	1.9	227
19(17, 2)-18(17, 1)	233212.37 (0.14)	3.8	211
19(4,16)-18(4,15)	233212.74 (0.03)	18.0	86
19(17, 3)-18(17, 2)	233222.42 (0.14)	3.8	211
19(16, 3)-18(16, 2)	233255.54 (0.09)	5.5	196
19(16, 4)-18(16, 3)	233268.95 (0.09)	5.5	196
19(15, 4)-18(15, 3)	233315.35 (0.06)	7.2	182
19(15, 5)-18(15, 4)	233331.57 (0.06)	7.2	182
19(14, 5)-18(14, 4)	233396.29 (0.05)	8.7	168
19(14, 6)-18(14, 5)	233414.76 (0.05)	8.7	168
19(13, 6)-18(13, 5)	233504.71 (0.05)	10.1	156
19(13, 7)-18(13, 6)	233524.87 (0.05)	10.1	156
17(9, 9)-17(8,10)	233578.70 (0.04)	7.4	100
17(9, 8)-17(8, 9)	233597.49 (0.04)	7.4	100
19(12, 7)-18(12, 6)	233649.77 (0.04)	11.4	144
19(12, 8)-18(12, 7)	233671.08 (0.04)	11.4	144
18(4,14)-17(4,13)	233753.95 (0.03)	17.2	79
26(21, 5)-27(20, 8)	233754.58 (4.84)	0.4	347
19(11, 8)-18(11, 7)	233845.21 (0.04)	12.6	134
19(11, 9)-18(11, 8)	233867.15 (0.04)	12.6	134
16(9, 8)-16(8, 9)	233959.18 (0.04)	6.7	93
16(9, 7)-16(8, 8)	233978.53 (0.04)	6.7	93
19(10, 9)-18(10, 8)	234112.42 (0.04)	13.7	124
19(10,10)-18(10, 9)	234134.53 (0.04)	13.7	124
15(9, 7)-15(8, 8)	234273.25 (0.04)	5.9	87
15(9, 6)-15(8, 7)	234293.17 (0.04)	5.9	87
9(5, 5)- 8(4, 4)	234479.63 (0.09)	4.7	30
19(9,10)-18(9, 9)	234486.57 (0.04)	14.7	115
19(9,11)-18(9,10)	234508.47 (0.04)	14.7	115
14(9, 6)-14(8, 7)	234529.48 (0.05)	5.2	80
14(9, 5)-14(8, 6)	234550.00 (0.05)	5.2	80
20(2,18)-19(3,17)	234726.59 (0.03)	11.8	89
13(9, 5)-13(8, 6)	234735.68 (0.05)	4.4	75
13(9, 4)-13(8, 5)	234756.79 (0.05)	4.4	75
19(8,11)-18(8,10)	235029.95 (0.04)	15.6	108
17(17, 0)-18(16, 3)	235050.00 (1.57)	0.0	196
19(8,12)-18(8,11)	235051.32 (0.04)	15.6	108
9(5, 4)- 8(4, 5)	235087.58 (0.09)	4.7	30
19(7,13)-18(7,12)	235866.04 (0.03)	16.4	101
19(7;12)-18(7,11)	235886.96 (0.03)	16.4	101
20(3,18)-19(3,17)	236355.91 (0.03)	19.3	89
19(5,15)-18(5,14)	236743.63 (0.03)	17.7	90
19(6,14)-18(6,13)	236800.43 (0.03)	17.1	95
21(1,20)-20(2,19)	237261.25 (0.03)	16.3	91
13(4,10)-12(3, 9)	237296.99 (0.05)	4.0	45
20(2,18)-19(2,17)	237297.46 (0.03)	19.3	89
21(2,20)-20(2,19)	237309.53 (0.03)	20.5	91
21(1,20)-20(1,19)	237344.89 (0.03)	20.5	91
21(2,20)-20(1,19)	237393.17 (0.03)	16.3	91
7(6, 2)- 6(5, 1)	237791.44 (0.13)	5.5	28
19(6,13)-18(6,12)	237807.69 (0.03)	17.1	95
22(0,22)-21(1,21)	238155.40 (0.04)	20.4	93
22(1,22)-21(1,21)	238155.90 (0.04)	21.8	93
22(0,22)-21(0,21)	238156.34 (0.04)	21.8	93
22(1,22)-21(0,21)	238156.84 (0.04)	20.4	93
7(6, 1)- 6(5, 2)	238488.05 (0.13)	5.5	28
20(3,18)-19(2,17)	238926.78 (0.03)	11.8	89
19(3,16)-18(3,15)	240021.08 (0.03)	18.3	85
26(1,25)-26(1,26)	240162.68 (0.11)	0.3	136
26(1,25)-26(0,26)	240162.72 (0.11)	3.0	136
30(3,27)-30(3,28)	240973.39 (0.11)	0.8	195
30(3,27)-30(2,28)	240982.78 (0.11)	9.0	195
30(4,27)-30(3,28)	241163.47 (0.11)	9.0	195
28(2,26)-28(2,27)	241334.76 (0.09)	0.6	165
28(2,26)-28(1,27)	241335.63 (0.09)	6.0	165
28(3,26)-28(2,27)	241362.71 (0.09)	6.0	165
28(3,26)-28(1,27)	241363.57 (0.09)	0.6	165
19(5,14)-18(5,13)	242871.52 (0.03)	17.7	91
20(4,17)-19(4,16)	244580.31 (0.03)	19.1	94
21(3,18)-20(4,17)	245138.29 (0.04)	8.7	102
20(19, 1)-19(19, 0)	245466.45 (0.33)	2.0	252
20(19, 2)-19(19, 1)	245467.92 (0.33)	2.0	252
20(18, 2)-19(18, 1)	245492.07 (0.20)	3.8	235
20(18, 3)-19(18, 2)	245498.11 (0.20)	3.8	235
25(5,20)-24(6,19)	245508.90 (0.17)	4.8	149
20(17, 3)-19(17, 2)	245530.23 (0.12)	5.6	219
20(17, 4)-19(17, 3)	245540.36 (0.12)	5.6	219
20(16, 4)-19(16, 3)	245583.79 (0.08)	7.2	204
20(16, 5)-19(16, 4)	245597.45 (0.08)	7.2	204
20(15, 5)-19(15, 4)	245656.57 (0.05)	8.8	190
20(15, 6)-19(15, 5)	245673.18 (0.05)	8.8	190
20(14, 6)-19(14, 5)	245753.84 (0.05)	10.2	176
20(14, 7)-19(14, 6)	245772.81 (0.05)	10.2	176
20(13, 7)-19(13, 6)	245883.01 (0.05)	11.6	164
20(13, 8)-19(13, 7)	245903.76 (0.05)	11.6	164
21(2,19)-20(3,18)	246027.54 (0.03)	12.9	97
20(12, 8)-19(12, 7)	246054.84 (0.04)	12.8	152
25(21, 5)-26(20, 6)	246075.92 (4.64)	0.3	336
20(12, 9)-19(12, 8)	246076.80 (0.04)	12.8	152
20(11, 9)-19(11, 8)	246285.47 (0.04)	14.0	142
20(11,10)-19(11, 9)	246308.10 (0.04)	14.0	142
10(5, 6)- 9(4, 5)	246456.53 (0.08)	4.7	34
20(10,10)-19(10, 9)	246600.16 (0.04)	15.0	132
20(10,11)-19(10,10)	246623.01 (0.04)	15.0	132
14(7, 8)-15(4,11)	246674.47 (0.16)	0.0	66
15(4,12)-14(3,11)	246675.31 (0.06)	4.5	57
19(4,15)-18(4,14)	246891.62 (0.03)	18.2	88
20(9,11)-19(9,10)	247040.77 (0.04)	16.0	124
21(3,19)-20(3,18)	247044.11 (0.03)	20.3	97
20(9,12)-19(9,11)	247063.46 (0.04)	16.0	124
10(5, 5)- 9(4, 6)	247242.03 (0.08)	4.7	34
21(2,19)-20(2,18)	247656.85 (0.03)	20.3	97
20(8,12)-19(8,11)	247682.65 (0.04)	16.8	116
20(8,13)-19(8,12)	247704.35 (0.04)	16.8	116
22(1,21)-21(2,20)	247873.98 (0.03)	17.3	100
22(2,21)-21(2,20)	247901.65 (0.03)	21.5	100
22(1,21)-21(1,20)	247922.26 (0.03)	21.5	100
22(2,21)-21(1,20)	247949.92 (0.03)	17.3	100
20(7,14)-19(7,13)	248633.58 (0.04)	17.6	109
21(3,19)-20(2,18)	248673.43 (0.03)	12.9	97
20(7,13)-19(7,12)	248744.68 (0.04)	17.6	109
23(0,23)-22(1,22)	248749.35 (0.04)	21.4	101
23(1,23)-22(1,22)	248749.62 (0.04)	22.8	101
23(0,23)-22(0,22)	248749.85 (0.04)	22.8	101
23(1,23)-22(0,22)	248750.12 (0.04)	21.4	101
20(5,16)-19(5,15)	249030.96 (0.03)	18.7	98
20(6,15)-19(6,14)	249578.02 (0.03)	18.2	103
30(10,20)-30(9,21)	249726.45 (0.20)	16.5	238
27(1,26)-27(1,27)	249883.26 (0.15)	0.3	146
27(1,26)-27(0,27)	249883.28 (0.15)	3.0	146
8(6, 3)- 7(5, 2)	250049.38 (0.12)	5.5	31
20(3,17)-19(3,16)	250246.46 (0.03)	19.2	93
16(4,13)-15(3,12)	250288.70 (0.06)	4.9	63
30(10,21)-30(9,22)	250678.30 (0.20)	16.5	238
8(6, 2)- 7(5, 3)	250730.69 (0.12)	5.5	31
28(6,22)-27(7,21)	251081.32 (0.32)	4.4	188
29(2,27)-29(2,28)	251138.25 (0.13)	0.6	176
29(2,27)-29(1,28)	251138.72 (0.13)	6.0	176
29(3,27)-29(2,28)	251154.49 (0.13)	6.0	176
29(3,27)-29(1,28)	251154.96 (0.13)	0.6	176
20(6,14)-19(6,13)	251264.51 (0.03)	18.2	103
29(10,19)-29(9,20)	251707.49 (0.24)	15.7	225
29(10,20)-29(9,21)	252238.83 (0.24)	15.7	225
28(10,18)-28(9,19)	253395.22 (0.26)	14.9	213
17(4,14)-16(3,13)	253605.99 (0.06)	5.5	70
28(10,19)-28(9,20)	253657.03 (0.26)	14.9	213
23(4,19)-22(5,18)	253718.32 (0.09)	6.5	125
27(10,17)-27(9,18)	254838.62 (0.20)	14.2	202
27(10,18)-27(9,19)	254938.76 (0.20)	14.2	202
21(4,18)-20(4,17)	255776.13 (0.03)	20.1	102
26(10,16)-26(9,17)	256072.93 (0.11)	13.4	190
26(10,17)-26(9,18)	256094.46 (0.11)	13.4	190

TABLE 3—*Continued*

ASSIGNMENT	FREQUENCY	S	E
18(4,15)-17(3,14)	256985.60 (0.07)	6.2	78
22(2,20)-21(3,19)	257064.43 (0.03)	13.9	106
25(10,16)-25(9,17)	257128.43 (0.08)	12.7	180
25(10,15)-25(9,16)	257132.38 (0.08)	12.7	180
20(5,15)-19(5,14)	257226.56 (0.03)	18.8	99
22(3,20)-21(3,19)	257690.32 (0.03)	21.3	106
21(20, 2)-20(20, 1)	257748.33 (0.55)	2.0	279
21(20, 1)-20(20, 0)	257752.77 (0.55)	2.0	279
21(19, 2)-20(19, 1)	257774.08 (0.35)	3.8	261
21(19, 3)-20(19, 2)	257774.95 (0.35)	3.8	261
21(18, 3)-20(18, 2)	257807.25 (0.22)	5.6	244
21(18, 4)-20(18, 3)	257812.98 (0.22)	5.6	244
21(17, 4)-20(17, 3)	257854.78 (0.14)	7.2	228
21(17, 5)-20(17, 4)	257864.82 (0.14)	7.2	228
21(16, 5)-20(16, 4)	257919.96 (0.09)	8.8	213
21(16, 6)-20(16, 5)	257933.73 (0.09)	8.8	213
21(15, 6)-20(15, 5)	258007.22 (0.06)	10.3	198
21(15, 7)-20(15, 6)	258024.11 (0.06)	10.3	198
24(10,15)-24(9,16)	258040.56 (0.06)	11.9	169
24(10,14)-24(9,15)	258050.08 (0.06)	11.9	169
22(2,20)-21(2,19)	258081.01 (0.03)	21.3	106
21(14, 7)-20(14, 6)	258122.69 (0.05)	11.7	185
21(14, 8)-20(14, 7)	258142.05 (0.05)	11.7	185
11(5, 7)-10(4, 6)	258152.89 (0.07)	4.8	39
21(13, 8)-20(13, 7)	258274.97 (0.05)	13.0	173
21(13, 9)-20(13, 8)	258296.20 (0.05)	13.0	173
23(1,22)-22(2,21)	258475.11 (0.04)	18.3	108
21(12, 9)-20(12, 8)	258476.61 (0.05)	14.2	161
23(2,22)-22(2,21)	258490.87 (0.04)	22.5	108
21(12,10)-20(12, 9)	258499.11 (0.05)	14.2	161
23(1,22)-22(1,21)	258502.78 (0.04)	22.5	108
23(2,22)-22(1,21)	258518.54 (0.04)	18.3	108
22(3,20)-21(2,19)	258706.90 (0.03)	13.9	106
21(11,10)-20(11, 9)	258746.44 (0.05)	15.3	151
21(11,11)-20(11,10)	258769.68 (0.05)	15.3	151
23(10,14)-23(9,15)	258837.55 (0.06)	11.2	159
23(10,13)-23(9,14)	258848.00 (0.06)	11.2	159
21(10,11)-20(10,10)	259114.18 (0.04)	16.3	141
21(10,12)-20(10,11)	259137.69 (0.04)	16.3	141
24(0,24)-23(1,23)	259341.93 (0.05)	22.4	110
24(1,24)-23(1,23)	259342.07 (0.05)	23.8	110
24(0,24)-23(0,23)	259342.20 (0.05)	23.8	110
24(1,24)-23(0,23)	259342.33 (0.05)	22.4	110
11(5, 6)-10(4, 7)	259444.96 (0.07)	4.8	39
20(4,16)-19(4,15)	259499.92 (0.03)	19.2	96
18(10, 9)-19(8,12)	259529.51 (0.10)	0.0	116
22(10,13)-22(9,14)	259530.10 (0.05)	10.4	150
22(3,19)-21(4,18)	259536.16 (0.04)	9.9	111
22(10,12)-22(9,13)	259540.62 (0.05)	10.4	150
28(1,27)-28(1,28)	259597.97 (0.20)	0.3	157
28(1,27)-28(0,28)	259597.98 (0.20)	3.0	157
28(2,27)-28(1,28)	259598.84 (0.20)	3.0	157
28(2,27)-28(0,28)	259598.84 (0.20)	0.0	157
21(9,12)-20(9,11)	259629.42 (0.04)	17.2	132
21(9,13)-20(9,12)	259652.84 (0.04)	17.2	132
21(10,12)-21(9,13)	260128.97 (0.05)	9.7	141
21(10,11)-21(9,12)	260139.52 (0.05)	9.7	141
21(3,18)-20(3,17)	260244.42 (0.04)	20.2	102
21(8,13)-20(8,12)	260384.19 (0.04)	18.0	125
21(8,14)-20(8,13)	260404.09 (0.04)	18.0	125
20(10,11)-20(9,12)	260644.13 (0.04)	9.0	132
20(10,10)-20(9,11)	260654.76 (0.04)	9.0	132
19(4,16)-18(3,15)	260793.36 (0.06)	7.0	86
30(2,28)-30(2,29)	260925.64 (0.18)	0.6	187
30(2,28)-30(1,29)	260925.89 (0.18)	6.0	187
30(3,28)-30(2,29)	260935.02 (0.18)	6.0	187
30(3,28)-30(1,29)	260935.28 (0.18)	0.6	187
19(10,10)-19(9,11)	261084.58 (0.04)	8.2	124
19(10, 9)-19(9,10)	261095.36 (0.04)	8.2	124
21(5,17)-20(5,16)	261148.87 (0.03)	19.8	107
21(7,15)-20(7,14)	261436.51 (0.04)	18.7	118
18(10, 9)-18(9,10)	261458.52 (0.04)	7.5	116
18(10, 8)-18(9, 9)	261469.51 (0.04)	7.5	116
21(7,14)-20(7,13)	261715.68 (0.04)	18.7	118
17(10, 8)-17(9, 9)	261773.43 (0.04)	6.8	109
17(10, 7)-17(9, 8)	261784.65 (0.04)	6.8	109
16(10, 7)-16(9, 8)	262036.14 (0.04)	6.0	102
16(10, 6)-16(9, 7)	262047.64 (0.04)	6.0	102
15(10, 6)-15(9, 7)	262252.93 (0.04)	5.3	95
15(10, 5)-15(9, 6)	262264.71 (0.04)	5.3	95
9(6, 4)- 8(5, 3)	262287.63 (0.11)	5.6	35
21(6,16)-20(6,15)	262324.81 (0.03)	19.3	112
14(10, 5)-14(9, 6)	262429.57 (0.04)	4.5	89
14(10, 4)-14(9, 5)	262441.64 (0.04)	4.5	89
9(6, 3)- 8(5, 4)	262951.58 (0.11)	5.6	35
21(6,15)-20(6,14)	265002.63 (0.03)	19.3	112
20(4,17)-19(3,16)	265352.60 (0.06)	8.0	94
7(7, 1)- 6(6, 0)	265418.91 (0.18)	6.5	34
7(7, 0)- 6(6, 1)	266208.98 (0.18)	6.5	34
22(4,19)-21(4,18)	266819.36 (0.03)	21.1	111
23(2,21)-22(3,20)	267926.80 (0.04)	15.0	115
23(3,21)-22(3,20)	268307.75 (0.04)	22.3	115
23(2,21)-22(2,20)	268552.69 (0.04)	22.3	115
23(3,21)-22(2,20)	268933.63 (0.04)	15.0	115
24(1,23)-23(2,22)	269069.12 (0.04)	19.3	117
24(2,23)-23(2,22)	269078.04 (0.04)	23.5	117
24(1,23)-23(1,22)	269084.88 (0.04)	23.5	117
24(2,23)-23(1,22)	269093.79 (0.04)	19.3	117
29(1,28)-29(0,29)	269307.22 (0.27)	3.0	167
29(1,28)-29(1,29)	269307.22 (0.27)	0.3	167
29(2,28)-29(0,29)	269307.69 (0.27)	0.0	167
29(2,28)-29(1,29)	269307.70 (0.27)	3.0	167
12(6, 7)-12(4, 8)	269308.42 (0.10)	0.0	49
12(5, 8)-11(4, 7)	269404.73 (0.06)	4.8	44
26(5,21)-25(6,20)	269525.60 (0.19)	5.6	160
25(0,25)-24(1,24)	269933.13 (0.06)	23.4	119
25(1,25)-24(1,24)	269933.20 (0.06)	24.8	119
25(0,25)-24(0,24)	269933.27 (0.06)	24.8	119
25(1,25)-24(0,24)	269933.34 (0.06)	23.4	119
22(21, 2)-21(21, 1)	270029.99 (0.93)	2.0	307
22(21, 1)-21(21, 0)	270041.77 (0.93)	2.0	307
22(20, 3)-21(20, 2)	270052.94 (0.64)	3.8	288
22(20, 2)-21(20, 1)	270058.61 (0.64)	3.8	288
22(19, 3)-21(19, 2)	270086.74 (0.43)	5.6	270
22(19, 4)-21(19, 3)	270086.76 (0.43)	5.6	270
22(18, 4)-21(18, 3)	270128.36 (0.29)	7.3	253
22(18, 5)-21(18, 4)	270133.56 (0.29)	7.3	253
22(3,19)-21(3,18)	270174.00 (0.04)	21.1	111
22(17, 5)-21(17, 4)	270186.33 (0.19)	8.9	237
22(17, 6)-21(17, 5)	270196.12 (0.19)	8.9	237
22(16, 6)-21(16, 5)	270264.44 (0.13)	10.4	222
22(16, 7)-21(16, 6)	270278.16 (0.13)	10.4	222
22(15, 7)-21(15, 6)	270367.79 (0.09)	11.8	207
22(15, 8)-21(15, 7)	270384.80 (0.09)	11.8	207
22(14, 8)-21(14, 7)	270503.43 (0.07)	13.1	194
22(14, 9)-21(14, 8)	270523.05 (0.07)	13.1	194
22(13, 9)-21(13, 8)	270681.31 (0.06)	14.3	182
22(13,10)-21(13, 9)	270702.90 (0.06)	14.3	182
21(4,18)-20(3,17)	270882.27 (0.06)	9.0	102
22(12,10)-21(12, 9)	270915.97 (0.05)	15.5	170
22(12,11)-21(12,10)	270938.92 (0.05)	15.5	170
22(11,11)-21(11,10)	271229.32 (0.05)	16.5	160
22(11,12)-21(11,11)	271253.08 (0.05)	16.5	160
21(5,16)-20(5,15)	271505.89 (0.03)	19.9	108
21(4,17)-20(4,16)	271524.74 (0.04)	20.2	105
22(10,12)-21(10,11)	271656.11 (0.05)	17.5	150
22(10,13)-21(10,12)	271680.22 (0.05)	17.5	150
12(5, 7)-11(4, 8)	271779.73 (0.06)	4.8	44
22(9,13)-21(9,12)	272255.01 (0.04)	18.3	141
22(9,14)-21(9,13)	272279.10 (0.04)	18.3	141
23(3,20)-22(4,19)	272864.46 (0.04)	11.1	120
24(4,20)-23(5,19)	272991.81 (0.09)	7.7	135
22(5,18)-21(5,17)	273078.64 (0.03)	20.8	116
22(8,14)-21(8,13)	273142.55 (0.04)	19.1	134
22(8,15)-21(8,14)	273151.31 (0.04)	19.1	134
22(7,16)-21(7,15)	274278.10 (0.04)	19.8	127
10(6, 5)- 9(5, 4)	274494.67 (0.11)	5.6	39
22(7,15)-21(7,14)	274816.74 (0.04)	19.8	127
22(6,17)-21(6,16)	275007.88 (0.03)	20.4	121
10(6, 4)- 9(5, 5)	275139.37 (0.11)	5.6	39
29(6,23)-28(7,22)	277410.37 (0.37)	5.0	200
22(4,19)-21(3,18)	277457.20 (0.05)	10.1	111
8(7, 2)- 7(6, 1)	277691.36 (0.17)	6.5	37
23(4,20)-22(4,19)	277733.02 (0.04)	22.1	121
8(7, 1)- 7(6, 2)	278464.57 (0.17)	6.5	37
24(2,22)-23(3,21)	278676.56 (0.04)	16.0	124
24(3,22)-23(3,21)	278906.12 (0.04)	23.3	124
30(1,29)-30(0,30)	279011.30 (0.36)	3.0	179
30(1,29)-30(1,30)	279011.31 (0.36)	0.3	179
30(2,29)-30(0,30)	279011.56 (0.36)	0.0	179
30(2,29)-30(1,30)	279011.56 (0.36)	3.0	179
22(6,16)-21(6,15)	279050.57 (0.03)	20.4	122

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TABLE 3—*Continued*

ASSIGNMENT	FREQUENCY	S	E
24(2,22)-23(2,21)	279057.51 (0.04)	23.3	124
24(3,22)-23(2,21)	279287.07 (0.04)	16.0	124
25(1,24)-24(2,23)	279658.58 (0.05)	20.3	127
25(2,24)-24(2,23)	279663.60 (0.05)	24.5	127
25(1,24)-24(1,23)	279667.50 (0.05)	24.5	127
25(2,24)-24(1,23)	279672.52 (0.05)	20.3	127
13(5, 9)-12(4, 8)	279975.33 (0.05)	4.8	49
23(3,20)-22(3,19)	280147.66 (0.04)	22.1	120
26(0,26)-25(1,25)	280522.93 (0.08)	24.4	128
26(1,26)-25(1,25)	280522.97 (0.08)	25.8	128
26(0,26)-25(0,25)	280523.00 (0.08)	25.8	128
26(1,26)-25(0,25)	280523.04 (0.08)	24.4	128
30(11,20)-30(10,20)	281624.31 (0.44)	5.3	247
30(11,19)-30(10,20)	281645.90 (0.40)	15.7	247
30(11,20)-30(10,21)	281710.87 (0.40)	15.7	247
30(11,19)-30(10,21)	281813.31 (0.44)	5.3	247
23(22, 2)-22(22, 1)	282312.94 (1.52)	2.0	336
23(21, 3)-22(21, 2)	282332.07 (1.11)	3.8	316
23(22, 1)-22(22, 0)	282333.76 (1.52)	2.0	336
23(21, 2)-22(21, 1)	282345.96 (1.11)	3.8	316
23(20, 4)-22(20, 3)	282361.67 (0.79)	5.6	297
23(20, 3)-22(20, 2)	282368.95 (0.79)	5.6	297
23(19, 5)-22(19, 4)	282403.54 (0.56)	7.3	279
23(19, 4)-22(19, 3)	282404.69 (0.56)	7.3	279
23(18, 5)-22(18, 4)	282455.70 (0.39)	8.9	262
23(18, 6)-22(18, 5)	282460.10 (0.39)	8.9	262
23(17, 6)-22(17, 5)	282525.24 (0.27)	10.4	246
23(17, 7)-22(17, 6)	282534.53 (0.27)	10.4	246
23(16, 7)-22(16, 6)	282617.64 (0.19)	11.9	231
23(16, 8)-22(16, 7)	282631.12 (0.19)	11.9	231
23(15, 8)-22(15, 7)	282738.75 (0.13)	13.2	217
23(15, 9)-22(15, 8)	282755.71 (0.13)	13.2	217
29(11,18)-29(10,19)	282871.43 (0.25)	15.0	235
29(11,19)-29(10,20)	282882.08 (0.25)	15.0	235
23(14, 9)-22(14, 8)	282896.64 (0.10)	14.5	203
23(14,10)-22(14, 9)	282916.37 (0.10)	14.5	203
22(4,18)-21(4,17)	282939.78 (0.04)	21.2	115
23(13,10)-22(13, 9)	283102.76 (0.08)	15.7	191
22(21, 1)-23(20, 4)	283123.80 (4.61)	0.1	307
23(13,11)-22(13,10)	283124.59 (0.08)	15.7	191
23(12,11)-22(12,10)	283373.86 (0.06)	16.8	180
23(12,12)-22(12,11)	283397.15 (0.06)	16.8	180
23(11,12)-22(11,11)	283735.34 (0.06)	17.8	169
23(11,13)-22(11,12)	283759.53 (0.06)	17.8	169
28(11,18)-28(10,19)	283937.70 (0.17)	14.2	223
28(11,17)-28(10,18)	283943.50 (0.17)	14.2	223
23(10,13)-22(10,12)	284227.72 (0.05)	18.7	159
23(10,14)-22(10,13)	284252.35 (0.05)	18.7	159
13(5, 8)-12(4, 9)	284398.17 (0.05)	4.8	49
23(5,19)-22(5,18)	284810.29 (0.04)	21.8	126
27(11,17)-27(10,18)	284879.53 (0.13)	13.5	211
27(11,16)-27(10,17)	284887.26 (0.13)	13.5	211
23(9,14)-22(9,13)	284920.35 (0.05)	19.5	151
23(9,15)-22(9,14)	284944.89 (0.05)	19.5	151
23(4,20)-22(3,19)	285016.22 (0.05)	11.2	121
24(3,21)-23(4,20)	285351.75 (0.05)	12.3	130
22(5,17)-21(5,16)	285515.70 (0.04)	21.0	118
26(11,16)-26(10,17)	285713.45 (0.10)	12.7	200
26(11,15)-26(10,16)	285720.60 (0.10)	12.7	200
23(8,16)-22(8,14)	285736.70 (0.28)	0.8	143
23(8,16)-22(8,15)	285940.81 (0.05)	20.2	143
23(8,15)-22(8,14)	285973.15 (0.05)	20.2	143
23(8,15)-22(8,15)	286089.82 (0.28)	0.8	143
25(11,15)-25(10,16)	286448.89 (0.08)	12.0	189
25(11,14)-25(10,15)	286455.22 (0.08)	12.0	189
11(6, 6)-10(5, 5)	286655.61 (0.11)	5.7	44
24(11,14)-24(10,15)	287095.15 (0.07)	11.3	179
24(11,13)-24(10,14)	287100.78 (0.07)	11.3	179
23(7,17)-22(7,16)	287146.45 (0.04)	20.9	137
11(6, 5)-10(5, 6)	287281.13 (0.11)	5.7	44
23(6,18)-22(6,17)	287592.80 (0.03)	21.4	131
23(11,13)-23(10,14)	287660.79 (0.06)	10.5	169
23(11,12)-23(10,13)	287665.86 (0.06)	10.5	169
23(7,16)-22(7,15)	288083.88 (0.04)	20.9	137
22(11,12)-22(10,13)	288153.61 (0.06)	9.8	160
22(11,11)-22(10,12)	288158.24 (0.06)	9.8	160
24(4,21)-23(4,20)	288541.48 (0.04)	23.1	130
21(11,11)-21(10,12)	288580.75 (0.05)	9.1	151
21(11,10)-21(10,11)	288585.04 (0.05)	9.1	151
20(11,10)-20(10,11)	288948.76 (0.05)	8.3	142
20(11, 9)-20(10,10)	288952.77 (0.05)	8.3	142
19(11, 9)-19(10,10)	289263.66 (0.05)	7.6	134
19(11, 8)-19(10, 9)	289267.47 (0.05)	7.6	134
25(2,23)-24(3,22)	289355.15 (0.05)	17.0	134
25(3,23)-24(3,22)	289492.25 (0.05)	24.3	134
18(11, 8)-18(10, 9)	289531.04 (0.05)	6.8	126
18(11, 7)-18(10, 8)	289534.67 (0.05)	6.8	126
25(2,23)-24(2,22)	289584.71 (0.05)	24.3	134
14(5,10)-13(4, 9)	289591.73 (0.04)	4.8	55
25(3,23)-24(2,22)	289721.81 (0.05)	17.0	134
17(11, 7)-17(10, 8)	289756.05 (0.05)	6.1	119
17(11, 6)-17(10, 7)	289759.55 (0.05)	6.1	119
16(11, 6)-16(10, 7)	289943.48 (0.05)	5.3	112
16(11, 5)-16(10, 6)	289946.87 (0.05)	5.3	112
9(7, 3)- 8(6, 2)	289957.07 (0.16)	6.5	41
15(11, 5)-15(10, 6)	290097.78 (0.05)	4.5	105
15(11, 4)-15(10, 5)	290101.06 (0.05)	4.5	105
24(3,21)-23(3,20)	290220.30 (0.05)	23.1	130
26(1,25)-25(2,24)	290244.97 (0.06)	21.3	136
26(2,25)-25(2,24)	290247.78 (0.06)	25.5	136
26(1,25)-25(1,24)	290249.99 (0.06)	25.5	136
26(2,25)-25(1,24)	290252.80 (0.06)	21.3	136
25(4,21)-24(5,20)	290695.42 (0.09)	8.9	145
9(7, 2)- 8(6, 3)	290711.20 (0.16)	6.5	41
27(0,27)-26(1,26)	291111.29 (0.09)	25.4	138
27(1,27)-26(1,26)	291111.30 (0.09)	26.8	138
27(0,27)-26(0,26)	291111.32 (0.09)	26.8	138
27(1,27)-26(0,26)	291111.34 (0.09)	25.4	138
27(5,22)-26(6,21)	292558.76 (0.21)	6.6	172
23(6,17)-22(6,16)	293388.53 (0.04)	21.5	131
24(4,21)-23(3,20)	293410.04 (0.05)	12.3	130
23(4,19)-22(4,18)	293764.48 (0.05)	22.1	125
24(22, 3)-23(22, 2)	294612.32 (1.80)	3.8	346
24(22, 2)-23(22, 1)	294636.52 (1.80)	3.8	346
24(21, 4)-23(21, 3)	294637.61 (1.34)	5.6	326
24(21, 3)-23(21, 2)	294654.22 (1.34)	5.6	326
24(20, 5)-23(20, 4)	294674.64 (0.98)	7.3	307
24(20, 4)-23(20, 3)	294684.04 (0.98)	7.3	307
24(19, 6)-23(19, 5)	294725.46 (0.72)	9.0	289
24(19, 5)-23(19, 4)	294728.21 (0.72)	9.0	289
24(18, 6)-23(18, 5)	294789.58 (0.52)	10.5	272
24(18, 7)-23(18, 6)	294792.82 (0.52)	10.5	272
24(17, 7)-23(17, 6)	294871.86 (0.37)	12.0	256
24(17, 8)-23(17, 7)	294880.36 (0.37)	12.0	256
24(16, 8)-23(16, 7)	294979.98 (0.26)	13.3	241
24(16, 9)-23(16, 8)	294992.97 (0.26)	13.3	241
24(15, 9)-23(15, 8)	295120.59 (0.18)	14.6	227
24(15,10)-23(15, 9)	295137.30 (0.18)	14.6	227
24(14,10)-23(14, 9)	295302.92 (0.13)	15.8	213
24(14,11)-23(14,10)	295322.59 (0.13)	15.8	213
24(13,11)-23(13,10)	295540.07 (0.10)	17.0	201
24(13,12)-23(13,11)	295561.98 (0.10)	17.0	201
24(12,12)-23(12,11)	295851.25 (0.08)	18.0	189
24(12,13)-23(12,12)	295874.76 (0.08)	18.0	189
24(11,13)-23(11,12)	296265.81 (0.07)	19.0	179
24(11,14)-23(11,13)	296290.33 (0.07)	19.0	179
24(5,20)-23(5,19)	296342.96 (0.04)	22.8	136
24(10,14)-23(10,13)	296830.89 (0.06)	19.8	169
24(10,15)-23(10,14)	296855.97 (0.06)	19.8	169
25(3,22)-24(4,21)	297213.44 (0.06)	13.4	140
14(5, 9)-13(4,10)	297513.23 (0.05)	4.7	55
24(9,15)-23(9,14)	297628.81 (0.05)	20.6	161
24(9,16)-23(9,15)	297652.97 (0.05)	20.6	161
15(5,11)-14(4,10)	297992.35 (0.05)	4.8	61
12(6, 7)-11(5, 6)	298747.51 (0.11)	5.8	49
24(8,17)-23(8,16)	298767.33 (0.07)	21.3	153
24(8,16)-23(8,15)	298893.46 (0.07)	21.3	153
23(5,18)-22(5,17)	299097.82 (0.05)	22.0	128
25(4,22)-24(4,21)	299268.23 (0.05)	24.1	140
12(6, 6)-11(5, 7)	299366.07 (0.11)	5.8	49

NOTE.—Transition frequencies in MHz. Energies (E) in cm^{-1}. Strengths (S) given are the standard line strength parameters (Townes and Schawlow 1955).

where the torsion-rotation term $\boldsymbol{H}_{tr}$ is given by

$$\boldsymbol{H}_{tr} = F \sum_{k=0}^{9} W_{v\sigma}^{(k)} (\boldsymbol{\rho} \cdot \boldsymbol{P})^k . \quad (2)$$

The first two terms of equation (1) are the standard rotation-centrifugal distortion A-reduced Hamiltonian of Watson (1968), plus a term in $\boldsymbol{P}^2$ (Gordy and Cook 1984). The remaining term is written in terms of the angular-momentum operator $\boldsymbol{P}$ and the vector $\boldsymbol{\rho}$, the components of which are given by

$$\rho_g = \lambda_g I_\alpha / I_g . \quad (3)$$

Here the λ_g are the direction cosines of the methyl group symmetry axis in the body-fixed principal-axis system, I_α is the methyl group moment of inertia about its symmetry axis, the I_g are the principal moments of inertia of the entire molecule, and F is the reduced rotational constant for the methyl group (Gordy and Cook 1984). In a prolate planar case such as methyl formate, λ_c vanishes.

The advantage of expressing the torsion-rotation interaction as in equation (2) is as follows: $\boldsymbol{H}_{tr}$ contains information about the asymmetry of the molecule only in the matrix elements of $\boldsymbol{\rho} \cdot \boldsymbol{P}$, whereas the dimensionless coefficients $W_{v\sigma}^{(k)}$ depend only on the reduced barrier height s (Gordy and Cook 1984). The parameter s is defined for a threefold torsional barrier in terms of F and the barrier height V_3 as

$$s = (4/9)(V_3/F) . \quad (4)$$

As realized by Herschbach (1959), this allows evaluation of the $W_{v\sigma}^{(k)}$ in the symmetric top limit, a fact which greatly simplifies the calculation. We have determined the $W_{v\sigma}^{(k)}$ using the internal axis method (IAM) program of Herbst (Herbst *et al.* 1984). The relation between the PAM coefficients and the IAM torsional eigenvalues in the symmetric top limit is given by Herschbach (1959).

Consideration of the torsional wave function symmetry leads to the fact that the $W_{v\sigma}^{(k)}$ vanish for odd-order k in the A state, and are of opposite sign for the two E states (Herschbach 1959). Because of the selection rule $\Delta\sigma = 0$, and since the even k terms in $\boldsymbol{H}_{tr}$ exhibit the same dependence on the $\boldsymbol{P}_g$ as the terms in $\boldsymbol{H}_{dist}$, analysis of the A state can be carried out without explicit mention of $\boldsymbol{H}_{tr}$. The "centrifugal distortion" constants obtained in the fit are, of course, actually linear combinations of the real distortion constants and the even-order $\boldsymbol{H}_{tr}$ constants. The favorable results of our analysis of the A state according to this approach have shown that the Van Vleck transformation method is reasonable in the case of methyl formate.

However, our determination of the rotational energies for the E states, in which the odd-order k terms of $\boldsymbol{H}_{tr}$ are present, employs further approximations. We have chosen to treat this term by retaining only those matrix elements of $\boldsymbol{H}_{tr}$ which connect K-doublet states (pairs of states corresponding to the same $|K|$ in the prolate limit). After diagonalization of the matrix $\boldsymbol{H}_{rot} + \boldsymbol{H}_{dist}$, these matrix elements are folded onto the diagonal with a series of 2×2 diagonalizations. An additional approximation used in our treatment is that the matrix elements of $\boldsymbol{H}_{tr}$ are evaluated in the symmetric top basis set rather than in the pseudorigid asymmetric rotor basis set. These matrix elements then appear as simple functions of J, K, and the parameters ρ_g (Herschbach 1959).

We have found that allowances for centrifugal distortion of the methyl group rotational constant F and the direction cosines λ_g enable us to make a more reliable set of frequency predictions; in the fitting routine, the independent parameters F and ρ_a are replaced by the forms

$$F' = F + \delta_F J(J+1) K^2 , \quad (5)$$

$$\rho_a' = \rho_a + \delta_\rho K^2 . \quad (6)$$

The rotational constants A, B, and C and 12 centrifugal distortion constants describe the unperturbed pseudorigid rotor energies, and five free parameters (F, s, ρ_a, δ_F, and δ_ρ) determine the shifts in these levels due to internal rotation. Results of the analysis and the derived rotational parameters are listed in Table 2.

III. DISCUSSION

Table 3 lists the ~1300 strongest transitions of methyl formate from 1 to 300 GHz in its ground torsional E substate with $J \leq 30$ and $E_{rot} \leq 350$ cm^{-1}. The line strengths S were calculated according to the definition of Townes and Schawlow (1955). To account for strong features due to the coincidence of two or more lines, "blend" strengths were calculated for each line by adding the quantity $\mu^2 S$ for lines within 1.5 MHz of one another. Here μ represents the appropriate dipole moment component (Bauder 1979). A lower limit of 2.0 was placed on the blend strengths; this limit corresponds to lines approximately 3 times weaker than the weakest lines assigned (at $E/k \sim 2T_{Orion}$) by Sutton *et al.* (1985) and Blake *et al.* (1986) in their Orion line search. The selection criteria match those of our previous listing of the spectrum of the A species.

The table includes the assignments, frequencies, uncertainties in the frequencies (1 σ), line strengths S, and excitation energies for the selected transitions. We note that as a result of mixing of the asymmetric top K-doublet wave functions, several unallowed asymmetric rotor transitions appear.

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